A HISTORY OF SCIENCE

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KEY AND INDEX

NEW YORK AND LONDON

HARPER & BROTHERS

PUBLISHERS MDCCCCX

DEDICATION

To the boys and girls of to-day, who hold all the possibilities of the future in their keeping.

To mothers and fathers, upon whom rests the vast responsibility of directing the minds and moulding the characters of the coming generation;

To educators by profession in every rank from kindergarten to university;

To members of the traditional "learned" professions, who are of necessity leaders of thought and formulators of ideals in the community; and

To intelligent men and women in any walk of life who aspire to keep abreast of their times and to broaden their horizons:

The books of this series, designed to contribute to the progress of civilization through the dissemination of useful knowledge, are dedicated.

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KEY AND INDEX VOLUME

A KEY TO THE TEXT

The present volume is devoted to Indexes which analyze the text of the preceding volumes from various standpoints.

Two of these indexes are of somewhat novel character, inasmuch as they introduce specific explanatory matter concerning technicalities of science, or biographical data regarding important scientific workers, in addition to guiding the reader to the pages of the preceding volumes.

The third Index is of more conventional character, and is designed solely as an analysis of the text; yet its references are always so phrased as to convey a clear idea of the exact subject to which the reader is guided.

AN ANALYSIS OF THE TEXT

As preliminary to these Indexes it will, perhaps, be a convenience to the reader to have presented here a very brief analysis of the varied contents of the preceding volumes from two different standpoints: First, a very general survey of the subjects treated; secondly, a more detailed presentation of these subjects as revealed by the titles of the successive chapters, volume by volume.

Perhaps the most general analysis that could be made of the text as a whole would characterize it as a comprehensive presentation of the growth of scientific

knowledge in all its departments, and the application of that knowledge to the affairs of every-day life.

So general a characterization, of course, can convey but a vague impression to the mind. To make this impression somewhat specific, let us say that there are six or seven large groups of subjects that form the theme of our successive chapters. These might be summarized in various ways, but perhaps the following somewhat arbitrary classification will serve as well as another:

1. Cosmical Sciences, as specifically represented by the science of astronomy, with its practical applications to the art of navigation. Here we have to do with the ferreting-out of the secrets of the starry universe and the planetary systems, from the visionary interpretations of the ancient Egyptian and Babylonian stargazers to the accurately measured records of the modern observer, equipped with telescope, spectroscope, and photographic plate, or with sextant and compass.

2. Telluric Sciences; specifically, geography, geology, paleontology, and meteorology. Here we deal with those studies through which a knowledge of the earth's geographic masses and of its rocky structure has been gained; with interpretations of the method of world-building that have been made possible by the study of fossil remains; and with the investigations of atmospheric phenomena to which the modern practical science of weather prediction owes its origin and its success.

3. Physical Sciences, or what the students of the elder day termed natural philosophy, including the phenomena of gravitation, heat, light, sound, and electricity and magnetism. This is a field at once of the most obvious interest and the utmost practical importance. Not only do its studies have to do with

the most familiar yet baffling and inscrutable of phenomena, but they deal also with the applications and transmutations of energy upon which practically all the mechanisms that perform the world's work depend—from water wheels and windmills to steam engines, gasoline motors, and electric dynamos.

4. Chemical Science, and the Chemical Industries. Here we have virtually an extension of the physical field to the world of the atom. We deal with inscrutable forces which have, nevertheless, the most tangible manifestations. Our studies range from the visionary dreams of the ancient alchemist, and the scarcely less mystical calculations of the modern student of atoms, valences, and periodic functions, to such highly practical fields as the work of electro-plating metals, compounding dye-stuffs, and manufacturing artificial gems in the laboratory.

5. Biological Sciences, including botany, zoology, biology proper, anatomy and physiology, medicine, experimental psychology, and anthropology. Here the very list of subjects is sufficiently explicative of the wide range of interests involved. We deal with the origins of life itself; with the evolution of species; with the applications of scientific knowledge to the conquest of disease; and with those subtle studies that are concerned with the brain itself and with the disembodied evidence of its functionings which we term the mind.

6. The Applied Sciences, or Mechanical Arts. Much that is implied by this title might properly be included, also, in the preceding ones. There are, however, a good many of the mechanical arts—for example, paper-making, printing, book-binding, the manufacture of cloth, the development of the flying-machine, and the like—that have depended for their development upon the ingenious application of familiar principles rather than upon any novel discovery. Yet

the story of the application of these principles is full of interest, and in many cases the ingenuity displayed in the application of old principles to new purposes is fully entitled to be described as the work of genius. Indeed such application of theoretical principles to the development of the practical mechanisms through which the entire structure of civilization has been developed constitutes the crowning achievement of scientific investigation.

CONTENTS BY CHAPTERS

The summary just presented will serve, perhaps, to give at least a general notion of the scope of our text. A notion still more precise may be gained from a survey of the contents of the successive volumes by chapters. Such a Table of Contents is here presented. By glancing at it the reader will be enabled to locate any specific subject as regards its main treatment. The list may, therefore, serve as an index of the most general character, preparatory for the detailed analyses made by the Indexes that follow, which are, as already noted, of three types:

I. Technical Index and Glossary, in which the technical terms of every department of science are defined, with illustrative comment.

II. Biographical Index: Comprising a full list of the discoverers in every department of science, theoretical and practical, with brief sketches of their work.

III. Encyclopædic General Index for the text volumes, covering fully all the topics treated, with abundant cross references.

It is unnecessary to characterize these indexes in detail, as their titles are in the main self-explanatory, and as the indexes themselves occupy the succeeding pages, making up the bulk of the present volume.

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TECHNICAL INDEX AND GLOSSARY

(Under this alphabet, technical and semitechnical terms are defined, with illustrative comment, and often with the addition of historical data. The references to the text, by volume and page, though specific, are intended rather as general guides to the reader than as offering a complete or detailed analysis of the subject.

For a more detailed analysis see the Encyclopædic General Index in this volume. For biographical data see the Biographical Index.)

Aberration. (1) In physics, that property of a lens in virtue of which it forms an image with color fringes, due to the fact that different rays of light are not brought precisely to the same focus. This difficulty is never entirely overcome even with the finest astronomical lenses. (2) In astronomy, the displacement of the apparent position of a celestial body due to the fact that the velocity of light is not infinite. See "Bradley and the Aberration of Light," Vol. III, p. 11.

Abrasives. Those substances used in grinding and polishing. See "Gems, Natural and Artificial," Vol. IX, p. 295; in particular p. 306; also "Glass and Glass Making," Vol. IX, p. 293.

Absolute Zero. The hypothetical condition of matter at which its molecules or atoms are in such a state of quiescence that they give out no heat. Theoretically this point lies 272° below the Centigrade zero; practically it has not been demonstrated in the laboratory. See "The Royal Institution and the Low Temperature Researches," Vol. V, Chapter 3; in particular p. 69.

Acetylene. A hydrocarbon gas, made commercially by adding water to calcium carbide; it has the chemical formula C_2H_2. See "The Introduction of Acetylene Gas," Vol. VI, p. 212.

Actinium. An element occurring in nature associated with zinc. Discovered in 1881 by Dr. T. L. Phipson. See "Element" and "Periodic Law," under present alphabet.

Aeroplane. The apparatus, consisting originally of a canvas plane or planes supported by poles and wires and actuated by motor-driven propellers, which constituted the first heavier-than-air machine in which human flight was accomplished. The

first successful aeroplane, that of the Wright Brothers (operated at Kitty Hawk, North Carolina, in December, 1903), had two chief planes, one above the other, and hence is called a biplane. The imitative machines of Farman, Curtiss, and Cody are also biplanes. The apparatus perfected by Blériot has a single chief plane, and is called a monoplane. The machine used by Hubert Latham is also a monoplane. The prototype of these machines is the original aerodrome of Langley, which was essentially a monoplane inasmuch as its two chief portions were arranged in the same horizontal plane. The box kite may be taken as the prototype of the biplane. See "The Triumph of the Aeroplane," Vol. VII, p. 272.

Air-pump. A machine by means of which air or other gases may be removed from an enclosed space. It was invented by Otto von Guericke about 1650. See "Mariotte and von Guericke," Vol. II, p. 210.

Air-thermometer. An instrument for measuring temperature, in which the change of volume of air under a constant pressure is made to indicate changes in temperature. The discovery that a gas expands at a uniform rate under increasing temperatures, and correspondingly contracts as temperatures decrease (constant pressure being maintained) was made independently by Boyle and Mariotte in the eighteenth century. See "The Successors of Galileo in Physical Science," Vol. II, p. 204 and p. 210.

Albinism. A condition in which there is a congenital absence of pigment in the hair, iris, and skin. It occurs in plants as well as animals, and in all races of men. Individuals so affected are called albinos. See the reference to the collection of specimens illustrating albinism (and the opposite state of melanism) in the Natural History Museum at South Kensington, London, Vol. V, p. 10.

Alchemy. The pseudo-science which sought to find a magic "elixir" or "philosophers stone" that would give its possessor the secret of eternal youth, and would also enable him to transmute silver and perhaps the baser metals into gold. For full treatment of the subject, see the chapter "Two Pseudo-Sciences—Alchemy and Astrology," Vol. II, p. 124.

Alcohol. The commercial name for ethyl alcohol, having the chemical formula $C_2H_5O\,H$. Alcohol results from the fermentation of sugars and starches, and is the intoxicating principle of wine and other beverages that were familiar from the earliest times; but the distilled spirit as such seems to have been dis-

covered, or at all events introduced to the Western world and named by mediæval Arabian physicians. See "Mediæval Science Among the Arabians," Vol. II, p. 22.

Alizarine. A substance formerly obtained from the root of the madder plant, Rubia tinctorum, but now chiefly produced from coal-tar. It has great commercial importance as a dye, producing the color known as "turkey red." The growth of the madder plant was formerly an important industry, but like the cultivation of the indigo plant, this pursuit has been made superfluous by the cheapness of the coal-tar colors. See "Pigments from Vegetable and Animal Sources," Vol. VIII, p. 302; in particular pp. 307-309.

Alloy. An intimate homogeneous mixture of different metals, usually produced by fusion. Thus brass is an alloy of copper and zinc; pewter, an alloy of tin and lead; steel, an alloy of iron and various other elements, chief among which are carbon, nickel, manganese, and tungsten. See chapter "The Age of Steel," Vol. VI, p. 271; in particular "The Conversion of Iron Ore into Iron and Steel," p. 283, and "Alloy Steels," p. 295.

Alternating current. The electrical current produced by a dynamo not provided with a commutator. See "The Mechanism of the Dynamo," Vol. VI, p. 173.

Aluminum. A nearly white metal, about as hard as silver, and having a tensile strength about equal to that of copper, but many times lighter in weight than either. It alloys with almost all the metals, and for this reason, and because of its lightness, is of great commercial importance. Aluminum oxides are the base of the important corundum group of gems, including true rubies, sapphires, and emeralds. See "The Ruby and Its Allies," Vol. IX, p. 319; also "Artificial Gems," Vol. IX, p. 331. Though aluminum is a chief constituent of clayey soils, its isolation has been difficult. For the electrolytic method of its production, see "Some Recent Triumphs of Applied Science," Vol. VI, p. 300.

Amethyst. A variety of corundum (a crystalline oxide of aluminum), its violet or purple color being due probably to traces of manganese or of iron. See "The Ruby and its Allies," Vol. IX, p. 319.

Ammonia. A gaseous compound of hydrogen and nitrogen, having the formula $N\,H_3$. It is supposed to derive its name from the fact that it was originally prepared near the temple of Ammon, in Egypt. Its composition was, of course, unknown until the time of the "pneumatic chemists" (including Black,

Cavendish, Priestley, Scheele, and Lavoisier), whose efforts laid the foundation for all modern knowledge of the gases about the close of the eighteenth century. For an account of their work, see "The Beginnings of Modern Chemistry," Vol. IV, p. 11.

Amoeba. A protozoan, which is present almost everywhere in fresh water, and in moist earth, and is usually taken as a type of unicellular animals. Certain forms of the Amoeba produce diseases, such as dysentery and abscess of the liver. Microscopic organisms were studied by such early microscopists as Leeuwenhoek (see Vol. II, p. 179) and Robert Hooke (see Vol. II, p. 217), but it remained for investigators of the nineteenth century to demonstrate their importance. See "Parasitic Diseases," Vol. IV, p. 204.

Anaesthetic. An agent used to produce loss or impairment of sensibility. The word was coined by Dr. Oliver Wendell Holmes. The use of ether, the most important general anaesthetic known, was discovered by Dr. W. T. G. Morton, a dentist, in 1842. The anaesthetic property of chloroform was discovered by Sir. J. Y. Simpson, of Edinburgh, in 1843. See "Painless Surgery," Vol. IV, p. 208.

Anastomosis. In anatomy, the joining of branches of a vessel with other vessels or branches. Hunter's discovery of the function of this anastomosis in arteries and veins marked an epoch in surgery. See Vol. IV, p. 82.

Aneurism. A disease (or injury) of the walls of an artery resulting in the formation of a pulsating tumor or sac. The English surgeon, John Hunter, about 1770, devised an operation for the cure of this condition, his discovery being the direct result of an operation performed on a deer in Richmond Park. See "Hunter's Operation for the Cure of Aneurism," Vol. IV, p. 81.

Aniline. An organic substance, with the formula $C_6H_5N\,H_2$. It was discovered in 1826, but was of no commercial importance until 1856, when W. H. Perkin prepared a purple dye from it. See "Coal-tar Colors," Vol. VIII, p. 311.

Animism. A system of philosophy introduced by Stahl, based on the idea that the soul is the seat of life. See "Eighteenth Century Medicine," Vol. IV, p. 185.

Annealing. A process for increasing the ductility of metals and glass. The usual method of annealing is by heating and then cooling slowly.

Anode. The electrode at which a current of positive electricity enters a battery. The other electrode is called the "cathode."

Anthrax. A disease affecting cattle, sheep, and men, known as malignant pustule, splenic fever, wool-sorter's disease, etc. It is very fatal, and caused by the bacillus anthracis. Protection by preventive inoculation was discovered by Pasteur. See Vol. IV, p. 232.

Anthropology. The branch of knowledge that deals with the characteristics of mankind as forming an organic whole. It considers the question of man's first appearance on earth, and the influences that have resulted in existing civilization. Scientific anthropology is a development of the late nineteenth century, the discoveries that proved man's antiquity preparing the way. See "Fossil Man," Vol. III, p. 98; also "The New Science of Anthropology," Vol. V, p. 228.

Antipyritics. The name given to those remedies used for reducing temperature in diseased conditions.

Antiseptic. A term meaning that which arrests decay. In modern medicine a substance which destroys disease-producing micro-organisms, or germs. The discovery of the use of antiseptics in surgery was made by Lord Lister, this discovery and its application bringing about a revolution in surgical methods. See "Lister and Antiseptic Surgery," Vol. IV, p. 229.

Antitoxins. Substances developed in the human body, or the body of an animal, antagonistic to the poisons (toxins) of disease. See "Serum Therapy," Vol. IV, p. 240; "Aims and Objects of the Pasteur Institute," Vol. V, p. 182.

Archæology. The science that deals with the history of human progress in ancient times, as judged by relics of man's work, apart from written records. See "The New Science of Oriental Archæology," Vol. IV, p. 287.

Argon. An element discovered in the earth's atmosphere by Sir William Ramsay and Lord Rayleigh. Named from the Greek word meaning "inactive," because of its lack of chemical affinity. See "Sir William Ramsay and the New Gases," Vol. V, p. 82; in particular pp. 85-86.

Armature. The name given originally to a piece of soft iron placed across the poles of permanent or electro-magnets to receive and concentrate the attractive force. In the modern dynamo, the armature consists of coils of wire which convey an electric current. The mutual relations of armature and electro-magnet (either of which may revolve, but one or the other being stationary) give rise to the accentuated electrical

current which it is the function of the dynamo to develop. See "The Mechanism of the Dynamo," Vol. VI, p. 173; also "Niagara in Harness," Vol. VI, p. 190.

Artificial Gems. See "Gems," in present glossary.

Artificial Stone, or Concrete. A stone-like substance made by mixing cement with sand and pebbles or broken stone. Cement itself is a mixture of powdered burnt clay, and powdered hydrates of lime. It was extensively used by the Romans, but little used by their successors until toward the close of the nineteenth century. Modern cements differ somewhat from the ancient and from one another, but all have as a base a mixture of argillaceous and calcareous minerals (clays and lime compounds). See chapter on "Artificial Stone, or Cement," Vol. IX, p. 182.

Astrolabe. An obsolete instrument for measuring the apparent angle between two visual (usually astronomical) bodies. The astrolabe, introduced about the middle of the fifteenth century, superseded the cross-staff as an aid to the navigator, and was in due course supplanted by the sextant. See "The Development of the Sextant," Vol. VII, p. 18.

Astrology. The pseudo-science that purports to study the stars and planets with the intent to forecast or interpret terrestrial events. Astrology flourished in Egypt and Babylonia and in the Western world throughout the Middle Ages. It numbered among its practitioners some astronomers of note, after the revival of learning, even including Kepler, who, however, was probably skeptical as to the validity of its claims. It gradually fell into disrepute with the advance of scientific knowledge. See "Two Pseudo-Sciences," Vol. II, p. 141.

Astronomy. The science that deals with the sidereal and planetary bodies. Observational astronomy reached a relatively high development in Egypt and Babylonia and was cultivated with great success by the Greeks of the Alexandrian epoch. The Arabs were adept star-gazers. But modern astronomy dates from Copernicus, Kepler, Galileo, and Tycho Brahe. The vast generalization of Newton gave it fresh impetus. Herschel's perfected telescope opened up new fields, with particular reference to nebulæ and double stars. Spectroscopy and photography in the nineteenth century still further widened the scope of the science. See "Egyptian Astronomy," Vol. I, p. 33; "Babylonian Astronomy," Vol. I, p. 61; for Greek Astronomy, Vol. I, p. 212; "Ptolemy, the Last Great Astronomer of Antiquity," Vol. I,

p. 267; Arabian Astronomy, Vol. II, p. 14; "Copernicus to Kepler and Galileo," Vol. II, p. 52; "Newton and the Law of Gravitation," Vol. II, p. 236; "The Successors of Newton in Astronomy," Vol. III, p. 3; "The Progress of Modern Astronomy," Vol. III, p. 19; "Solar and Telluric Problems," Vol. V, p. 205. Numerous minor references might be added, but the above outline the main story of astronomical progress.

Atlantic Cable. The first cable across the Atlantic was projected by Cyrus W. Field in 1856. After unsuccessful efforts, the first electric message was sent across the ocean in August, 1858. This cable soon parted, however, and a permanent connection was not established till 1866. See "The Submarine Cable," Vol. VIII, p. 30.

Atmosphere. The "ocean of air in which we live" has been investigated scientifically chiefly within the past century. Its composition, as regards the chief constituents, oxygen and nitrogen, was determined toward the close of the eighteenth century; but the minor gases, argon, neon, crypton, and xenon, escaped detection for about a hundred years, when they were discovered by Lord Rayleigh and Sir William Ramsay. See Vol. V, p. 82. For meteorological aspects of the atmosphere, see Vol. III, p. 168.

Atom. The unit structure of matter as viewed by the chemist. The atomic theory of matter in its modern scientific development dates from the time of John Dalton, who propounded the theory in 1803. See "John Dalton and the Atomic Theory," Vol. IV, p. 38.

Atomic weights. Each specific atom has a definite weight, which chemists have been at great pains to discover. For table of atomic weights, see "Element," in the present glossary.

Aurora Borealis. A manifestation of lights seen at irregular intervals toward the polar regions; believed to be of electrical origin. The most recent explanation of the phenomenon is that of Arrhenius, who thinks the light due to electrons thrown out from the sun and accumulated in the upper atmosphere, where, under magnetic influence, they tend to move toward the poles. See "The Aurora Borealis," Vol. III, p. 172.

Automatic Coupling. A life and limb saving device for coupling freight cars without the direct intervention of human hands. An effective coupler was introduced by Eli Janney in 1879. See "Automatic Couplings," Vol. VII, p. 147.

Automobile. The familiar self-propelled vehicle, actuated

usually by a gasoline engine, but sometimes by steam or by electricity, sprang into popularity in the last decade of the nineteenth century, but its prototypes (propelled by steam) were made more than a hundred years earlier. See "The Coming of the Automobile," Vol. VII, p. 156.

Axe. This familiar implement is essentially a sharp wedge operated at the end of a lever. Its use dates from the Rough Stone Age. See "Applications of Muscular Energy," Vol. VI, p. 52.

Babylonian Medicine. The practice of medicine in Babylonia-Assyria was closely bound up with astrology and magic; yet it had certain more scientific aspects. See "Chaldean Magic," Vol. I, p. 69, and "Babylonian Medicine," Vol. I, p. 75.

Babylonian Science. The science of the Chaldeans, Babylonians, and Assyrians is usually somewhat vaguely included under this title. Our knowledge of the subject depends partly upon Greek traditions (Herodotus, Diodorus), and partly upon recently exhumed archæological remains. See "Science of Babylonia and Assyria," Vol. I, p. 56.

Bacteria. Microscopic vegetable organisms, which play an all-important part in the economy of nature, causing putrefactive changes, contagious diseases, etc. Discovered by Leeuwenhoek in 1683. Their real importance was unsuspected until late in the nineteenth century. For the importance of the part played by bacteria in surgery, and the discovery of a method of combatting their effect, see "Lister and Antiseptic Surgery," Vol. IV, p. 229. For recent studies in pathogenic bacteria, see "Some Medical Laboratories and Medical Problems," Vol. V, p. 182.

Barometer. An instrument for measuring the weight of the atmosphere; in its simplest form, a vacuum tube closed at one end and inverted over a dish of mercury; the height to which the mercury rises in the tube demonstrates the atmospheric pressure, which varies with the altitude and with the amount of moisture in the air. Invented by Torricelli in 1643. See "Torricelli," Vol. II, p. 120; also Pascal's test of the barometer by ascending a mountain and noting the lowering of the column of mercury, see Vol. II, p. 122.

Bicycle. A familiar two-wheeled vehicle, the most primitive form of which (termed the hobby horse) was introduced by Baron Von Drais in France about the year 1818. The halting stages by which the machine was perfected illustrate the rarity

of creative imagination. See "From Cart to Automobile," Vol. VII, p. 152.

Biograph. An apparatus for producing "moving pictures," familiar under various names. The germ of the instrument was invented as long ago as 1833, but the developed apparatus came into being late in the nineteenth century. For the story of its development, see "Chrono-photography," Vol. VIII, p. 248.

Biology. A generic name for the sciences that deal with living things, including botany, zoology, physiology, in their various departments, and in the widest interpretation, medicine, anthropology, and ethnology. The word biology was introduced independently by Lamarck and Treviranus early in the nineteenth century, but did not come at once into general use. See "Schleiden and Schwann and the Cell Theory," Vol. IV, p. 118. For the work of Lamarck, Goethe, Darwin, and others, see "Theories of Organic Evolution," Vol. IV, p. 140.

Blast Furnace. A furnace for smelting ores, so called because of the blast of air forced through the furnace to promote combustion by bringing oxygen in contact with the fuel; or through the molten metal itself, as in the manufacture of steel. See "The Conversion of Iron Ore into Iron and Steel," Vol. VI, p. 283.

Blood Corpuscles. Microscopic cells that float in the blood and perform functions absolutely essential to the life of the organism. The red blood corpuscles are the carriers of oxygen; the white corpuscles, of several types, are scavengers, attacking and consuming noxious bacteria. For a description of the discovery of the course of circulation of the blood, and the final demonstration of the corpuscles passing through the capillaries, see "The Coming of Harvey," Vol. II, p. 169. For an explanation of the function of blood corpuscles, see "Blood Corpuscles, Muscles, and Glands," Vol. IV, p. 135.

Brain. In general terms, that part of the cerebrospinal axis which is contained in the cranium. For functions of, see "The New Science of Experimental Psychology," Vol. IV, p. 245.

Bronze. A compound of metals, having copper for its base, the other ingredient being usually tin. The proportion of copper in various bronzes is usually between 80 and 90 per cent. Copper melts at a temperature a little below that of gold, and the ease with which it is smelted led (as is believed) to its use long before the art of smelting iron had been acquired.

Calcium Carbide. A compound of calcium and carbon ($Ca\,C_2$), produced in the electric furnace by heating a mixture of lime and coke. When brought in contact with water, a chemical recombination is effected whereby acetylene gas ($C_2\,H_2$) is produced. The change is chemically expressed thus: $Ca\,C_2 + H_2\,O = C_2\,H_2 + Ca\,O$. See "The Introduction of Acetylene Gas," Vol. VI, p. 212.

Calotype Process. A photographic process invented by Fox Talbot (q. v.); the prototype of modern paper-printed photographs, as distinguished from the metallic-surface process of Daguerre. See "Talbot's Calotype Process," Vol. VIII, p. 227.

Camera Lucida. An instrument in which, through the use of prisms, light is refracted and reflected in such a way as to throw the image of a landscape or other view on a ground-glass plate, where its outlines may be readily sketched.

Camera Obscura. Essentially, as its name implies, a dark chamber, into which a single ray of light is admitted through a pinhole aperture. The small aperture has the effect of a lens, and an image of the scene outside is thrown on the wall of the chamber opposite the aperture. The photographic camera is a modified camera obscura, in which the light is focused by a lens. It is possible to take a photograph, of rather vague outline, by using a very small aperture, without a lens.

Candle. This familiar modified form of lamp, consisting essentially of a wick embedded in a solid cylinder of wax, tallow, or other easily liquefied, inflammable fat, was invented late in the twelfth century. For centuries it was the best of lighting apparatuses, and it has by no means been supplanted altogether even in our day. For the general description of methods of illumination, past and present, see "The Banishment of Night," Vol. VI, p. 201.

Carbonic Acid Gas. A compound of carbon and oxygen, having the formula $C\,O_2$. It is given off through the lungs by animal organisms, and is absorbed by plants, which thus secure the carbon that enters so importantly into the vegetable structure. Another and still more poisonous compound of carbon oxygen is known as carbonic oxide ($C\,O$). Both these gases are sometimes present in mines. See "Conditions to be Considered in Mining," Vol. VI, p. 247, and "The Function of Respiration," Vol. IV, p. 92.

Cathode Rays. A peculiar manifestation of energy due to passing an electrical current through a vacuum tube. These rays cast a shadow and are deflected by a magnet; and, by im-

pinging on the glass receptacles, they generate X-rays. See "Professor J. J. Thomson and the Nature of Electricity," Vol. V, p. 92, for the investigations of Crookes, Leonard, Röentgen, Becquerel, Thompson, and others.

Cell. (1) The unit structure of living tissues. See Vol. IV, p. 115, for the investigations of Brown, Schleiden, Schwann, Von Mohl, and Virchow; also "The Mechanism of the Cell," Vol. V, p. 225. (2) The unit structure of a galvanic battery as devised originally by Galvani and Volta. See "Electricity," of the present index.

Centrosome. A minute structure (discovered by Van Beneden) within the organic cell, the precise function of which is in doubt.

Chemical Affinity. A term designating the attractive and selective influence that operates between chemical substances. The preference of the various chemical atoms are perfectly definite and unvarying, under given conditions, and the entire science of chemistry is built upon the knowledge of such interrelations between the different elementary atoms; but this knowledge is, in each case, matter of experimental observation. See "Chemical Affinity," Vol. IV, p. 57.

Chemistry. The science that deals with the interrelations of the different kinds of matter, as regards their elementary or atomic structure. The border-line between chemistry and physics is not always quite sharply defined (as, for example, in the matter of radio-activity, which encroaches upon both domains), but in general chemistry deals with atoms themselves; physics with the aggregations of atoms which we call molecules. Thus it was the province of the chemist to determine that water is a compound of hydrogen and oxygen, and that air is a mixture of nitrogen, oxygen, and other gases; while the study of such things as hydrostatic pressure, the expansion of gases, etc., belongs to the physicist. See "The Beginnings of Modern Chemistry," Vol. IV, p. 11, and "Chemistry Since the Time of Dalton," Vol. IV, p. 38.

Chimney. This seemingly essential architectural element of the dwelling-house was not known in antiquity, but was developed in the Middle Ages, or at the beginning of the modern period. See Vol. IX, p. 150.

China. A name applied to various kinds of glazed pottery, the exact implications of the word not being very closely defined. See "The Products of Clay and Fire," Vol. IX, p. 227.

Chisel. This familiar implement for gouging and cutting wood,

indispensable to the carpenter, is really a sharp-edged wedge, and operates on the principle of the inclined plane. It has been used, practically unmodified, from a very early period.

Chloroform. A compound prepared by cautiously distilling together a mixture of alcohol, water, and chloride of lime. Chemical symbol $C\,H\,Cl_3$. The use of chloroform as an anæsthetic was introduced by the Scottish surgeon, Sir J. Y. Simpson; not, however, until the anæsthetic power of ether had been clearly demonstrated by Morton in America. See "Painless Surgery," Vol. IV, p. 208.

Choke-damp. A colloquial name for carbonic acid gas ($C\,O_2$) when found in mines. The name is used (in contradistinction to the explosive "fire-damps") because this gas is non-explosive, but may cause death by asphyxiation—literally choking the miner to death. See "Conditions to be Considered in Mining," Vol. VI, p. 247.

Chromosomes. Minute, usually thread-like structures within the organic cell nucleus, which have peculiar interest because their number varies in different animals, but is always the same for each cell of any given species. The chromosomes are bisected when the cell divides. See pp. 131-134 of Vol. V for recent researches in this field.

Chronometer. Generically, any time-measurer; but specifically a name for the nautical watch or clock carried in duplicate or triplicate by navigators and explorers, which records the time at a given meridian (usually that of Greenwich), thus supplying information with the aid of which the navigator may compute his longitude from sidereal observations. See "Perfecting the Chronometer," Vol. VII, p. 23.

Chrono-photography. Generic name applied to the method of taking series of photographs at brief intervals, to the end that "moving pictures" may be produced. The apparatuses with which these pictures are reproduced are familiar under the trade names of kinetoscope, biograph, vitascope, etc. Names of Muybridge, Marey, Anschütz, and Edison are associated with the invention. See "Chrono-photography—Moving Pictures," Vol. VIII, p. 248.

Circuit. The medium or mediums connecting the poles of a battery or other generator of electricity. The ground, or a body of water, may serve as the medium of the so-called "return circuit"; but some conducting medium must give unbroken communication (however circuitous the route) or the current will

not "flow." See "The Experiments of Stephen Gray," Vol. II, p. 262; "The Transmission of Power," Vol. VI, p. 194.

Civilization. Name somewhat loosely applied to the most recent stage of ethnical development, in contradistinction to "savagery" and "barbarism." In the terminology of some ethnologists, the word "civilized" is reserved for peoples that have acquired the art of writing.

Clock. The modern apparatus bearing this name is usually actuated either by weight and pulley, by pendulum, or by coiled springs. The most familiar type, the pendulum clock, was invented by Huyghens in 1656. The clypsedra, or water clock, was the most usual time-measurer throughout antiquity. See "Instruments of Precision in the Age of Newton," Vol. II, p. 256.

Coal-tar Colors. Pigments of an almost infinite variety of colors and shades of color produced from the distillation products of coal-tar, the basal form of which is known as aniline. The first commercially important aniline color was produced by Perkin in 1856. In recent years, coal-tar colors have revolutionized the indigo and alizarine industries. See "The Coal-tar Colors," Vol. VIII, p. 311.

Coherer. A very delicate instrument, in the original Marconi system, consisting essentially of brass filings in a vacuum tube, with the aid of which the Hertzian waves used in wireless telegraphy are detected. Coherers were invented independently by Prof. D. E. Hughes (1880) and Dr. Branly (1890-91). See "Wireless Telegraphy," Vol. VIII, p. 52.

Cohesion. The property in virtue of which bodies tend to hold together. The precise nature of this inter-molecular force is not clearly established; it may be identical with gravitation.

Collodion-emulsion Process. A photographic process dependent upon the use of sensitized emulsion, the basis of which is collodion. The process was introduced by Bolton and Sayce in 1864, and gave a new impetus to photography. Subsequently, gelatine was very generally substituted for collodion in making the emulsion. See "Photography in its Scientific Aspects," Vol. VIII, p. 231.

Color-photography. The attempt to reproduce the natural colors photographically has enlisted the efforts of a large number of experimenters, but as yet has met with only partial success, although very beautiful glass "positives" may now be made with comparative ease by the Lumière "autochrome" process. See "Photographing in Natural Colors," Vol. VIII, p. 234.

Foundation of Mechanics," Vol. I, p. 196; and "Inclined Planes and Derricks," Vol. IX, p. 37.

Cross-staff. A primitive apparatus for measuring the angle between two visual objects, such as two stars, or a star and the horizon-line. It was used by navigators from an early period, but was ultimately superseded by astrolabe (fifteenth century) and quadrant (eighteenth century). See "The Development of the Sextant," Vol. VII, p. 18.

Crowbar. A simple lever, which, now made of iron or steel instead of wood, performs the same service for the modern workman that it did for his prehistoric ancestor.

Cupping-glass. A glass cup, which becomes a suction apparatus through the exhaustion of air within it; much used by physicians in the days when venesection was in vogue, but now practically obsolete.

Cyclone. A revolving atmospheric current, describing a circle that may be a few feet or many miles in diameter. The universality of cyclonic air currents was first prominently taught by H. W. Dove, about 1827. See "Cyclones and Anti-cyclones," Vol. III, p. 199.

Daguerreotype. The form of photograph (using a metal surface, and giving a reversed image) invented by Louis J. M. Daguerre about 1839. The process is still much employed for the cheap photographs called tin-types. See "Photography in its Scientific Aspects," Vol. VIII, p. 224.

Darwinian Theory. The theory of evolution (which owed its development to Charles Darwin, though independently conceived by Alfred Russell Wallace), which explains organic evolution as due in a large measure to the preservation of favorable varieties or stocks through "natural selection." The essentials of the theory, stated in a phrase, are spontaneous (i.e., unexplained) variation, and (in Herbert Spencer's phrase) the "survival of the fittest." Perhaps no other theory in the entire history of thought ever had so important an influence on the ideas of a generation as this theory exercised. See "Theories of Organic Evolution," Vol. IV, p. 140.

Derrick. See Crane.

Diamond Drill. A drill for boring through rock, the cutting edge being made of a ring of black diamonds. See "The Mineral Depths," Vol. VI, p. 247, and "Other Sources of Diamonds; Practical Uses," Vol. IX, p. 317.

Direct Current. A current of electricity generated by a dynamo provided with a system of commutators through which the electric impulses are made to flow in one direction, instead of oscillating as they do in the so-called alternating current. For fuller information see the subject "Electricity," and its various departments.

Dissipation of Energy. See Energy.

Dissociation. A hypothetical chemical process (so named by Ste. Claire Deville), according to which the chemical atoms in any compound are constantly separating and reuniting. See "Chemical Affinity," Vol. IV, p. 57.

Ductless Glands. Certain glands in the animal body that have no excretory ducts, their functions being performed through the channels of the vascular and lymphatic vessels. The spleen, the thyroid gland, and the supra-renal capsules are important examples of this type of gland. See "Blood Corpuscles, Muscles, and Glands," Vol. IV, p. 135.

Dye. The generic name given to coloring matters in transparent mediums; suitable therefore for coloring fabrics or staining surfaces without providing a protective covering such as is given by paints proper. The distinction between dyes and paints is, however, not always very clearly adhered to. See "Paints, Dyes, and Varnishes," Vol. VIII, p. 314.

Dynamics. The science that deals with the motions of bodies, and with the forces that actuate these motions; in contradistinction to "statics," which deals with stationary bodies.

Dynamo. The apparatus, consisting essentially of a coil of wire conveying a current of electricity and made to revolve in a magnetic field, which transforms molar energy (usually supplied by a steam engine or by a water-wheel) into electrical energy. The multitudinous practical applications of electricity to the supplying and transmitting of power (trolleys, elevators, etc.) are dependent upon the dynamo, the perfecting of which took place late in the nineteenth century. See "Man's Newest Co-laborer: The Dynamo," Vol. VI, p. 171. For Faraday's experiments leading up to the development of the dynamo, see "Faraday and Electro-magnetic Induction," Vol. III, p. 240.

Dynamo-electric Machines. Name originally applied to all machines intended to perform work with the aid of electricity, subsequently contracted to "dynamo."

Electric Light. The light engendered by rendering a badly-conducting material incandescent by passing a current of electricity through it. The possibility of producing light in this way was discovered by Davy early in the nineteenth century; but no commercial use was made of the discovery till the middle of the century; and the first important commercial light (the Jablochkoff "candle") was not invented till 1876. Brush's arc light followed; and Edison's incandescent light is still more recent. See "The Banishment of Night," Vol. VI, p. 218.

Electricity. A familiar but inscrutable manifestation of energy, having for its unit structure, according to the most recent theory (J. J. Thomson), an infinitesimal corpuscle, or electron. Frictional electricity (e.g., due to rubbing amber) was known to the ancients; galvanic electricity was discovered by Galvani and Volta; dynamic electricity has been placed at the service of man in our own generation. For the earliest experiments in electricity, see "William Gilbert and the Study of Magnetism," Vol. II, p. 111; also, "Progress in Electricity from Gilbert and Von Guericke to Franklin," Vol. II, p. 259; "The Modern Development of Electricity and Magnetism," Vol. III, p. 229; "Prof. J. J. Thomson and the Nature of Electricity," Vol. V, p. 92. For such subjects as "The Electric Telegraph," "Electric Railways," "Electric Lighting," the reader is referred to chapters under these headings in this index and the general index.

Electric Railways. Electricity as a traction power owes its popularity simply to the fact that it can be transmitted conveniently to a distance over a wire (trolley) or third rail, or (less importantly) in a so-called storage battery. The initial experiments in this line were made as early as 1835 (Thomas Davenport); a little later (1847-1857), Thomas Hall, Dr. Colton, and Prof. C. C. Page continued the work, followed by a host of others. Galvanic cells and storage batteries were first used with some success, but the dynamo presently superseded other generators, although the storage battery, as perfected by Edison, again entered the field prominently in 1910. See "The Development of Electric Railways," Vol. VII, p. 175.

Electro-chemistry. An important branch of practical chemistry, that finds application in a multitude of commercial industries. The activities involved are chiefly either (1) the principle of electrolysis, whereby chemicals are dissociated (as, for

example, in copper-plating, silver-plating, etc.) in solution; or (2) the agency of high temperatures, as developed in the electric furnace, whereby substances are decomposed and purified or allowed to reunite in new compounds. See "Humphry Davy and Electro-chemistry," Vol. IV, p. 46. The use of electro-chemistry is the development of the first telegraphs. See "Galvanism Gives a New Stimulus to Inventors," Vol. VIII, p. 11. In connection with the reproduction of illustrations, see "The Introduction of Process Work," Vol. VIII, p. 202.

Electrolysis. The dissociation or decompounding of substances in solution through the passage of electric currents. In a solution of silver salts, for example, the silver (being "electro-positive") passes to the negative pole (cathode) and is there deposited. This is the action in the practical process of electro-plating. Similarly, solutions of copper compounds are used to plate surfaces with copper, as in making the plates from which books, half-tone pictures, etc., are printed. See "The Introduction of Process Work," Vol. VIII, p. 202. Cavendish's decomposition of the water atom by the use of electricity, Vol. IV, p. 14. See also "Electro-chemistry" of this index.

Electro-magnetism. A manifestation of energy due to the curious relations that exist between magnetism and electricity, whereby, under certain circumstances, one may be induced by the other. See "Faraday and Electro-magnetic Induction," Vol. III, p. 240. See also in the present index, "Dynamo," "Electricity," "Electron," "Hertzian Waves."

Electron. The hypothetical unit structure of electricity, the theory of which has been chiefly developed by Prof. J. J. Thomson. The negative electron is believed to have about one one-thousandth the mass of the hydrogen atom. It may be the basis of all matter. Professor Thomson made tentative announcement of the probable discovery of the positive electron in 1910. See "Professor J. J. Thomson and the Nature of Electricity," Vol. V, p. 92.

Electro-plating. See Electrolysis.

Element. The final chemical analysis, so far as at present achieved, resolves all known forms of matter into seventy-odd so-called elements, each having an atomic structure, which resists further dissociation, and which presents definite and characteristic properties of size and chemical valency. Their names and atomic weights are:

Aluminum	Al	27.1
Antimony	Sb	120.2
Argon	A	39.9
Arsenic	As	75.
Bromine	Br	79.96
Barium	Ba	137.4
Beryllium	Be	9.1
Bidymium	Di	142.
Bismuth	Bi	208.5
Boron	B	11.
Cadmium	Cd	112.4
Caesium	Cs	133.
Calcium	Ca	40.1
Carbon	C	12.
Cerium	Ce	140.
Chlorine	Cl	35.45
Chromium	Cr	52.1
Cobalt	Co	59.
Columbium	Cb	93.5
Copper	Cu	63.6
Dysprosium	Dy	162.5
Erbium	Er	166.
Europium	Eu	152.
Fluorine	F	19.
Gadolinium	Gd	156.
Gallium	Ga	70.
Germanium	Ge	72.5
Gold	Au	197.2
Helium	He	4.
Hydrogen	H	1.008
Indium	In	114.
Iodine	I	126.85
Iridium	Ir	193.
Iron	Fe	55.9
Krypton	Kr	87.8
Lanthanum	La	138.9
Lead	Pb	206.9
Lithium	Li	7.03
Lutecium	Lu	174.
Magnesium	Mg	24.36
Manganese	Mn	55.
Mercury	Hg	200.
Molybdenum	Mo	96.
Neodymium	Nd	143.6
Neon	Ne	20.
Nickel	Ni	58.7
Niobium	Nb	94.
Nitrogen	N	14.04
Osmium	Os	191.
Oxygen	O	16.
Palladium	Pd	106.5
Phosphorus	P	31.
Platinum	Pt	194.8
Potassium	K	39.15
Praseodymium	Pr	140.5
Radium	Ra	225.
Rhodium	Rh	103.
Rubidium	Rb	85.4
Ruthenium	Ru	101.7
Samarium	Sm	150.
Scandium	Sc	44.1
Selenium	Se	79.2
Silicon	Si	28.4
Silver	Ag	107.93
Sodium	Na	23.05
Strontium	Sr	87.62
Sulphur	S	32.06
Tantalum	Ta	183.
Tellurium	Te	127.6
Terbium	Tb	160.
Thallium	Tl	204.1
Thorium	Th	232.5
Thulium	Ta	171.
Tin	Sn	119.
Titanium	Ti	48.1
Tungsten	W	184.
Uranium	U	238.5
Vanadium	V	51.2
Xenon	X	128.
Ytterbium (Neoytterbium)	Yb	173.
Yttrium	Y	89.
Zinc	Zn	65.4
Zirconium	Zr	90.6

Etching. A process of engraving, in which the artist scratches the waxed surface of the metallic plate with a pointed instrument, the mechanical process being completed by the action of acids, which "bite" the plate only in places thus exposed. See "Etching," Vol. VIII, p. 195.

Ether. The hypothetical substance filling all space, "penetrating between the molecules of matter as air between the leaves of trees." One theory of matter supposes all material substances to be composed of vortex rings of ether. Undulations in the ethereal medium are supposed to constitute the manifestations which our senses interpret as light and radiant heat. For the investigation of the early workers, such as Young and Clerk-Maxwell, to the most recent, see "The Ether and Ponderable Matter," Vol. III, p. 283.

Evolution, The Theory of Organic. The doctrine which teaches that higher organic forms have developed sequentially from lower ones, through various channels, all of which lead back to a primordial form of proto-plasmic being. See Darwin, Erasmus Darwin, Lamarck, Haeckel, and "Theories of Organic Evolution," Vol. IV, p. 140.

Faraday Tubes. Lines of magnetic force, as observed by Faraday, and theoretically explained by him. These "tubes" radiate in all directions into space, in loops of all sizes, which connect the poles of a magnet. They have been invoked to explain many phenomena of nature, including "action at a distance." See "Modern Views," Vol. VI, p. 153.

Fire-damp. Name given by miners to the explosive or inflammable gases that sometimes develop in mines, in contradistinction to the non-explosive carbonic acid gas, which they term "choke damp." See "Carbon Dioxide Gas," of the present index.

Fossil Beds. Strata containing large numbers of fossils; usually from remains originally deposited in an ancient lake bed. Some of the most important fossil beds are found in the Rocky Mountain region. See "The New Science of Paleontology," Vol. III, p. 74.

Fossil Horse. Remains of this animal, as found in the fossil beds of western America, had peculiar interest, as they gave tangible evidence of the truth of the evolution of hypothesis. See "The New Science of Paleontology," Vol. III, p. 105.

Fossil Man. Remains of prehistoric man, study of which has demonstrated the great antiquity of the human race. Finds of

this character are always of interest, but are no longer startling as they were at the middle of the nineteenth century, when the "age of man" was supposed to compass a mere six thousand years. See "The New Science of Paleontology," Vol. III, p. 98.

Friction. The motion-retarding influence exerted by one surface against another, or by a gas or liquid acting on another gas or liquid or on a solid. Friction is responsible for enormous loss of power in the operation of all working mechanisms; but, on the other hand, were it not for friction man would not be able to handle tools, or even to walk. See "Other Means of Transmitting Power," Vol. VI, p. 35.

Ganglion Cells. Central nerve cells, located in the brain, the spinal cord, or in the outlying plexuses, which serve as storehouses of nervous energy. See "Functions of the Nerves," Vol. IV, p. 259.

Gas. Matter in the state of tennosity in which its component molecules, instead of being relatively close together and more or less subject to the influence of cohesive forces (solids, liquids), are widely separated, and in rapid linear motion, darting hither and thither, and rebounding on contact. (See Maxwell; Kinetic theory.) All kinds of matter assume the gaseous state under proper conditions of pressure and temperature. Substances that are gaseous at ordinary terrestrial temperatures are spoken of as "permanent gases," but the term is a misnomer. For Clerk-Maxwell's kinetic theory of gases, see Vol. III, p. 295. For the "Law of Avogadro," see Vol. IV, p. 57. For recent experiments in liquifying gases, see Vol. V, p. 53. For some recent discoveries of new gases, see Vol. V, p. 84.

Gas Engine. An engine actuated by some gas other than steam. Gas engines are of recent development; the best-known form being the explosion engine generally used for automobiles and motor boats. See "Gas and Oil Engines," Vol. VI, p. 132.

Gas Mantle. A mantle, of which that of Herr Welsbach is the type, composed of an earth (e.g., a compound of thorium and cerium) which becomes incandescent when heated in a gas flame; giving far more light than would be produced by the gas flame itself. See "The Incandescent Gas Mantle," Vol. VI, p. 208.

Gastric Juice. The digestive juice secreted by the stomach. It is acidulous (hydrochloric acid) and its most characteristic and important constituent is the ferment pepsin. See "The Chemical Theory of Digestion," Vol. IV, p. 88.

Gears. Mechanisms for transmitting power, or for changing the direction of its action. The toothed wheel and the bitted wheel are typical examples. See "Other Means of Transmitting Power," Vol. VI, p. 35.

Gems. Minerals, usually in crystalline form, the combined beauty and rarity of which gives them great commercial value, usually quite without regard to any question of practical utility. The diamond (a crystal of pure carbon) owes its popularity to its hardness, combined with its high index of refraction; the true ruby, sapphire, and emerald are crystallized oxides of aluminum (corundum) with traces of different coloring matters. Stones of the corundum order are now duplicated in the laboratory on a commercial scale; but laboratory diamonds are as yet of infinitesimal size. See "Gems, Natural and Artificial," Vol. IX, p. 295.

Geocentric Theory. The theory according to which the earth is the center of the solar system. This theory has universal vogue (notwithstanding the protest of Aristarchus) throughout antiquity; the true heliocentric theory was put forward by Copernicus. See "Aristarchus of Samos, the Copernicus of Antiquity," Vol. I, p. 212.

Geology. The science that deals with the origin, structure, and metamorphoses of the earth's crust. It is, in any comprehensive sense, a modern science, its correct theories dating from the close of the eighteenth century. See "The Origin and Development of Modern Geology," Vol. III, p. 116.

Geometry. Literally, and in its earliest applications, the science of earth measurement. As such its elements were understood by the ancient Egyptians. Expanded and its chief propositions formulated by the Alexandrian, Euclid (300 B.C), whose exposition is still used in modern text-books. See "Euclid," Vol. I, p. 192.

Germanium. See "Elements" in the present index.

Glands. Secretory organs, of which there are many types, as, for example, the salivary glands, the peptic glands of the stomach, the pancreatic glands, and sundry intestinal glands. See also "Ductless Glands" of the present index.

Glass. A crystalline substance, the chief constituent of which is silica (sand), with which varying proportions of potash, soda, and lime are combined. See "Glass and Glass-Making," Vol. IX, p. 277.

Glass Negatives. See "Photography" in the present index.

Histology. The science that deals with the minute structure of animal and vegetable tissues. This science depends very largely upon the microscope, and has developed chiefly since that instrument was perfected. See "Lister and the Perfected Microscope," Vol. IV, p. 109.

Horse Power. The unit of work, as applied by Watt to the steam engine. Watt assumed that a horse could perform an amount of labor equivalent to the raising of 33,000 pounds to the height of one foot in one minute; this was doubtless an over-estimate, but it has remained the standard. See Vol. VI, p. 60.

Hot-air Engine. An engine in which heated air is used instead of steam or exploded gas to propel the piston. See "Gas and Oil Engines," Vol. VI, p. 132.

Hydrophobia. See "Rabies" in the present index.

Hydrostatic Press. An apparatus for transmitting power; it makes use of the principle that pressure applied to a given surface of a liquid is transmitted unmodified to each corresponding surface of the enclosing well. In practice a small force applied to a small piston in a cylinder becomes multiplied as transmitted to the large piston of a connecting cylinder. See "Hydraulic Power," Vol. VI, p. 74.

Hydrostatics. The science that deals with the properties of fluids. For Archimedes's solution of some of the most important problems of hydrostatic equilibrium, see Vol. I, p. 196. For the experiments of Galileo, see "Galileo and the Equilibrium of Fluids," Vol. II, p. 105.

Hygiene. The science of health; in particular having to do with improvements in living, ventilation, sanitation, etc. See "The Berlin Institute of Hygiene," Vol. V, p. 193.

Hypnotism. Name given by Dr. Braid to the practice of inducing artificial somnambulism in a susceptible subject. The hypnotic condition is subjective, and is indeed by suggestion, not by the giving out of any "magnetic" or other occult influence on the part of the hypnotist. See "Physiological Psychology," Vol. IV, p. 266.

Inclined Plane. A familiar mechanism through the use of which heavy bodies may be raised to a height with a conservative use of power. Diodorus Siculus records that the Egyptian utilized the principle of the inclined plane in building the pyramids. See "Inclined Planes and Derricks," Vol. VI, p. 37.

Induction, Electric. A curious phenomenon, in which an elec-

tric current is generated in a coil of insulated wire wound about another coil, through which a current generated in the usual way is passed. The familiar Faradic current is thus induced. For a description of the discovery of induction, see "Progress in Electricity from Gilbert and Von Guericke to Franklin," Vol. II, p. 259. For Faraday's experiments, see Vol. III, p. 240.

Inorganic Matter. Mineral compounds of whatever character that have been developed or compounded without the aid or interposition of living organisms, vegetable or animal.

Interference of Light. The collision of one wave of light (etherial undulation) with another in such a way as to obstruct the wave, causing darkness. Studies of interference led Young to the elaboration of the undulatory theory of light. See "Thomas Young and the Wave Theory of Light," Vol. III, p. 215.

Isomerism. A word coined by the chemist Berzelius to indicate the fact, demonstrated in 1823 by Liebig and Wohlen, that two substances exhibiting different physical properties may have precisely the same chemical composition. See "Organic Chemistry and the Idea of the Molecule," Vol. IV, p. 53.

Julian Calendar. The reformed calendar of Julius Cæsar, which adopted the Alexandrian expedient of introducing an additional day every fourth (leap) year. For comparison of this calendar and with that of the ancient Egyptian calendar, see "Astronomical Science," Vol. I, p. 33.

Kinematograph. See Chrono-photography, Vol. VIII, p. 248.

Kinetic Theory (of gases). The theory that a gas consists of molecules in a state of agitation, describing a "free path" of relatively great length between successive impacts with other molecules. See Vol. III, p. 295.

Knitting Machinery. A machine for knitting stockings was invented by a Scottish clergyman, William Lee, in 1589; a development that permitted the knitting of a ribbed surface was introduced by Jedediah Strutt in 1758; and the circular knitter (producing a seamless stocking) was perfected by Peter Claussen in 1845. See "Lace Making and Knitting Machinery," Vol. IX, p. 55.

Krupp Steel. An alloy steel, containing nickel, which adds to its hardness and gives it great value for armoring ships. See "The Age of Steel," Vol. VI, p. 295.

Lamp, Safety. A lamp invented by Humphry Davy, for use in mines, to give protection against danger from explosion due to "fire-damp." The device consists essentially of enclosing the lamp in wire gauze. See "Conditions to be Considered in Mining," Vol. VI, p. 247.

Latent Heat. A term introduced by Dr. Joseph Black to apply to the modicum of heat which seemingly disappears or becomes latent when a substance changes its physical state, as, for example, when water is transformed into steam. The heat reappears when the steam is retransformed into water. Black's studies in this field were probably a source of inspiration to his friend Watt, in connection with the perfecting of the steam engine. See Vol. VI, p. 94.

Latitude. Distance north or south from the equator, measured in degrees, minutes and seconds of arc. Latitude is determined with comparative ease by the mariner through observation of the height of the sun at meridian, as measured with the sextant. See "The Development of the Sextant," Vol. VII, p. 18.

Law, Natural. The expression of an observed sequence of phenomena in nature, so often repeated that we are justified in regarding the sequence as inevitable.

Lever. An instrument which, in various modified forms, is the most universally employed of all instruments with which work is performed. The principles of the lever were formulated by Archimedes. See "How Work is Done," Vol. VI, p. 29.

Leyden Jar. Name given a simple apparatus for storing electricity generated by a friction machine, as discovered independently by Dean Von Kleist and Pieter von Musschenbrock in 1745. The original apparatus of Von Kleist consisted simply of a nail or a piece of brass wire placed in a glass bottle. See "The Leyden Jar Discovered," Vol. II, p. 280.

Light. The phenomena interpreted by the eyes as light and color consists essentially of undulations in the ether, having clearly defined upper and lower limits of frequency. This explanation of light was demonstrated by Young and Fresnel; and their theory supplanted the corpuscular or emanation theory that had been championed by Newton. The undulations in the ether that are interpreted as light are induced by vibrations of molecules of matter ordinarily produced by excessive heat; in other words, light is a manifestation of energy. See "Modern Theories of Heat and Light," Vol. III, p. 206.

Lightning. A manifestation of atmospheric electricity, as was

Low Temperature Researches. The work of Rumford, Davy, and Young, and later by Sir James Dewar and his associates in reducing gases, even hydrogen itself, to a liquid state, is described in "The Royal Institution and the Low Temperature Researches," Vol. V, p. 29.

Magdeburg Hemispheres. The name given two hollow brass hemispheres with tightly-fitting surfaces which, when approximated, and after the air had been exhausted, could not be pulled apart by teams of horses. With these Otto von Guericke, in the seventeenth century, demonstrated atmospheric pressure. See Vol. II, p. 211; Vol. VI, p. 66.

Magnet. A body which possesses the property of attracting fragments of iron or steel. The loadstone is a natural magnet. It is the native magnetic oxide of iron, Fe_3O_4. See "Electricity," and "Electro-magnetism" of the present index.

Magnetism. The property possessed by certain bodies whereby they naturally attract or repel one another. See "Faraday and Electro-magnetic Induction," Vol. III, p. 240. Also "Electricity," and "Electro-magnetism" of the present index.

Magnetized Needle. A magnet in the form of a needle suspended at its center of gravity, which places itself naturally in a position with its long axis nearly north and south, with one end inclining downward. See "Electricity and Magnetism," Vol. III, p. 236. Also "The Mariner's Compass," Vol. VII, p. 7.

Mammalia (mammiferous animals, mammals). All those animals which suckle their young, and no others. Thus, whales, although fish-like in habits, are mammals quite as much as horses or cattle. For studies of fossil mammals, see "The New Science of Paleontology," Vol. III, p. 74; and "The Origin and Development of Modern Geology," Vol. III, p. 116.

Mantle, Gas. A porous, hollow cone, or bag-shaped structure, composed of the oxides of thoria, alumina, magnesia, etc., which when placed so that a mixture of air and illuminating gas passes through it, and is ignited, becomes brilliantly luminous. See "Gas Lighting," Vol. VI, p. 207.

Mariner's Compass. An instrument, apparently invented and used by the Chinese before the Christian era, in which a magnetized needle suspended at its center of gravity above a disk, is used for determining directions at sea. The short-needle compass, now used universally, was invented by Lord Kelvin about 1875. See "The Mariner's Compass," Vol. VII. p. 7.

Marine Galvanometer. An instrument consisting of a tiny magnet and a reflector with which telegraphic messages are magnified by reflected light. With this instrument, the invention of Lord Kelvin, very weak currents of electricity can be utilized for signaling. See "Instrumental Aids," Vol. VIII, p. 45.

Medicine. For the story of the development of the science of medicine, from the earliest time until the present, see "Scientific Knowledge of the Egyptian Physician," Vol. I, p. 49; "Babylonian Medicine," Vol. I, p. 75; "Empedocles, Physician, Observer, and Dreamer," Vol. I, p. 132; "Hippocrates and Greek Medicine," Vol. I, p. 170; "Galen, the Last Great Alexandrian," Vol. I, p 278; "Arabian Medicine," Vol. II, p. 21; "Byzantine, and Thirteenth Century Medicine," Vol. II, p. 31; "From Paracelsus to Harvey," Vol. II, p. 156; "Medicine in the Sixteenth and Seventeenth Centuries," Vol. II, p. 181; "Eighteenth Century Medicine," Vol. IV, p. 182; "Nineteenth Century Medicine," Vol. IV, p. 200. Also see chapters on Anatomy and Physiology of the eighteenth and nineteenth centuries.

Mercury-vapor Light. An electric light, invented by Mr. Peter Cooper Hewitt, in which mercury vapor enclosed in a glass tube is made incandescent by the passage of an electric current. This type of lamp produces eight times as much light as the ordinary carbon filament lamp with the same amount of power. See "The Mercury-vapor Light of Peter Cooper Hewitt," Vol. VI, p. 236.

Meteorites, or Shooting Stars. Mineral or metallic masses, of extraterrestrial origin, which fall upon the earth, or are consumed while passing through the atmosphere toward the earth. See "The New Science of Meteorology," Vol. III, p. 168.

Meteorology. The science which treats of the motions and phenomena of the earth's atmosphere, the study of climate and weather, their causes, changes, and effects. See "The New Science of Meteorology," Vol. III, p. 168.

Mezzotint. A method of engraving on copper or steel, the surface of which has been uniformly roughened by an instrument called a "cradle" or "rocker." For dark tones the surface is left undisturbed, the lighter effects being produced by scraping away the surface. See "Mezzotint," Vol. VIII, p. 196.

Micrometer. An instrument, used in connection with the microscope, for measuring lengths and angles.

Microscope. An optical instrument for magnifying minute objects. Invented in 1590 by the Dutch optician Jensen. Im-

proved by Robert Hooks, and finally brought to its present state of perfection by the efforts of Sir David Brewster, Dr. Wollaston, Coddington, and Joseph Jackson Lister. See "Lister and the Perfected Microscope," Vol. IV, p. 109.

Milky Way. A luminous band in the heavens, composed of stars and nebulæ. This fact was discovered by Galileo with the telescope which he invented. See Vol. II, p. 79; and the general treatment of modern astronomy, "The Progress of Modern Astronomy," Vol. III, p. 19.

Molecule. The smallest mass of any substance that can exist in a separate form. The atom is, of course, smaller, but single atoms cannot exist alone. See "The Ether and Ponderable Matter," Vol. III, p. 283.

Monorail Systems. Railways having a single rail, on which cars with double-flanged wheels are kept in a state of equilibrium either by overhead supports, or by means of a gyroscope. The Gyrocar (q.v.) of Louis Brennan is an example of this latter type. See "The Gyrocar," Vol. VII, p. 195; and "Monorail Systems," Vol. VII, p. 191.

Moon's Variation, which was discovered by an Arabian astronomer about 975, is the inequality of motion of the moon, in virtue of which it moves quickest when new or full, and slowest at first and third quarter. Later (about 1750) this fact was rediscovered by Tycho Brahe. For modern studies of the moon, see "Studies of the Moon," Vol. III, p. 48.

"Mule." A spinning machine invented by Samuel Crompton about 1779. As it was a combination of the spinning-jenny and Arkwright's drawing-rollers—a hybrid machine—it was dubbed "mule," after that hybrid animal. See "The Invention of the 'Mule,'" Vol. IX, p. 32.

Multiple Messages. In telegraphy it is possible to send several messages at the same time in opposite directions over a single wire. The first machine for doing this was invented by an Austrian, Dr. Gintl, in 1853. See "Multiple Messages," Vol. VIII, p. 25.

Muscles. A kind of animal tissue capable of contracting in length and dilating in breadth. The voluntary muscles, as the biceps of the arm, are under control of the will, while the involuntary muscles, such as those of the heart, intestines, etc., are not. All muscles respond to electrical stimuli. See "The Animal Machine," Vol. VI, p. 43.

Muscular System. The term applied to all muscles of the body as distinguished from the nervous system, osseous system, etc.

Nautical Almanac. An almanac published by the United States and other maritime powers, for the use of astronomers and navigators, in which is given the angular distances of the moon from the sun, planets, and fixed stars, etc., and other information that enables the navigator to determine exact positions of latitude and longitude. See "The Conquest of the Zones," Vol. VII, p. 37.

Neolithic Civilization. A term applied especially to the civilization of northwestern Europe during the epoch of highly finished and polished stone implements. It was the later period of the "stone age," the earlier period being the Paleolithic age.

Neon. A gaseous element discovered in the earth's atmosphere by Ramsay and Travers in 1898. See "Some Physical Laboratories and Physical Problems," Vol. V, p. 84.

Neptune. (1) In Roman mythology the god of the sea; (2) in astronomy the most distant of the known planets. It is peculiar in revolving from east to west, and revolves around the sun in 164.6 years. See "The Discovery of Neptune," Vol. III, p. 42.

Neptunists. The name given to the followers of Werner of Saxony, who believed that "in the beginning all the solids of the earth's crust were dissolved in the heated waters of a universal sea." The opponents of this theory, who followed James Hutton's teachings, were called "Plutonists." See "Neptunists versus Plutonists," Vol. III, p. 131.

Nerve Cells. Structures in the brain from which the nerve-filaments originate. They may be likened to "a central telephone office of a telephone system." See "The New Science of Experimental Psychology," Vol. IV, p. 249.

Nerves. Filaments leading from the nerve cells of the brain to various structures of the body, such as muscles, glands, etc., which serve as conductors of impulses, to and from the brain. Sir Charles Bell, in 1811, discovered that there are two distinct sets of nerves, one for carrying motor and the other for carrying sensory impulses. See "Experimental Psychology," Vol. IV, p. 249.

Nitrate Beds. Large areas in northern Chili, Peru, and Bolivia, containing sodium nitrate ($NaNO_3$) in a native state. This substance is valuable as a fertilizer, and as a source of

nitric acid and of nitre. See "Nitrogen from the Air," Vol. VI, p. 303.

Nitrogen. A gaseous, non-metallic element, constituting 77 per cent by weight, or four-fifths by bulk, of the earth's atmosphere. Discovered by Henry Cavendish about 1809. See "Henry Cavendish," Vol. IV, p. 13; and "Nitrogen from the Air," Vol. VI, p. 303.

Nuclei of Plant Cells. The component part of the vegetable cell, first recognized by Robert Brown in 1833. See "Robert Brown and the Cell Nucleus," Vol. IV, p. 115.

Oil Engines. See "Gas and Oil Engines," Vol. VI, p. 132.

Organic Evolution. The changes in living organisms, the outgrowth of which is their present forms. See "Theories of Organic Evolution," Vol. IV, p. 140.

Organic Matter. The term applied to animal and vegetable matter as distinguishing it from mineral, or inorganic, matter.

Organicists' System. A system of medicine in vogue during the eighteenth century, the followers of which did not believe that life was due to some spiritual entity, but rather to the structure of the body itself. See "Animists, Vitalists, and Organicists," Vol. IV, p. 184.

Oxygen. A non-metallic gaseous element, discovered in 1774 by Joseph Priestley, and called by him "dephlogisticated air." Later Lavoisier gave it the name oxygen (chemical symbol O). See "Joseph Priestley," Vol. IV, p. 18.

Paint. Colors or dyes mixed with some vehicle, such as oil, turpentine, water, etc., so as to spread over a surface and retain their brilliancy after drying. See "Paints, Dyes, and Varnishes," Vol. VIII, p. 258.

Paleontology. The science of ancient life that inhabited the earth during the ages previous to historic times. The science originated early in the nineteenth century and was named by de Blainville and Fischer von Waldheim in 1834. See "The New Science of Paleontology," Vol. III, p. 74.

Palladium. A metal resembling platinum, used in the manufacture of certain scientific instruments. It was discovered by Wollaston in 1803. See "Element" of the present index.

Paper. A material composed of vegetable fibers formed artificially into thin sheets. It came into use about the twelfth century in Europe, but was probably known and used long

before that in the Orient. See "The Manufacture of Paper," Vol. VIII, p. 159.

Parasitic Diseases. Diseases caused by animal or vegetable parasites, such as the itch, caused by the burrowing under the skin of the itch mite, or the disease trichinosis, due to the presence of trichinæ burrowing in the tissues. See "Parasitic Diseases," Vol. IV, p. 204.

Pepsin. A ferment secreted by the mucous lining of the stomach, discovered by Schwann and Wasmann, 1836-1840. When combined with an acid solution it has the power of transforming coagulated albuminous substances into soluble peptones. See "Animal Chemistry," Vol. IV, p. 128.

Percussion. In medicine, the method of investigation which consists in striking the surface of the body to ascertain from the sounds produced the condition of the parts beneath. Introduced in modern times by Avenbrugger, and afterward adopted by Laënnec and Corvissart. See "Nineteenth Century Medicine," Vol. IV, p. 199.

Periodic Law. A term expressive of the observed fact that the chemical elements when listed serially in the numerical order of their atomic weights show a curious recurrence of similar properties at intervals of eight elements. See "Periodicity of Atomic Weights," Vol. IV, p. 64.

Periscope. An optical instrument used for making observasions from a submarine boat when submerged. See "Submarine Vessels," Vol. VII, p. 93; in particular p. 111.

Phantoscope. A form of moving-picture machine. See "Chrono-photography—Moving Pictures," Vol. VIII, p. 248.

Phlogiston. A hypothetical substance, at one time supposed to be part of all bodies capable of being burned. The Phlogiston theory was developed by George Ernst Stahl (1660-1734), following the experiments of Becker (1635-1682). See "The Phlogiston Theory in Chemistry," Vol. IV, p. 3.

Phonautograph. An instrument invented by Leo Scott in 1856, with which vibrations made by sounds were recorded on smoked glass by means of a needle attached to a diaphragm. See "The Edison Phonograph," Vol. VIII, p. 93.

Phonograph. A device for recording and reproducing sounds, invented by Thomas A. Edison in 1877. See "The Edison Phonograph," Vol. VIII, p. 93.

Photography. The art of producing pictures by the action of light on chemically prepared surfaces. The first camera image

was produced by Niepce in 1827; but the honor of bringing photography to a practical stage of development belongs to Daguerre, dating from January, 1839. See "Photography in its Scientific Aspects," Vol. VIII, p. 220.

Photogravure. A process of engraving, done partly by photography, and by mechanical and chemical action on copper plates, from which prints can be made in a copper-plate press. See "The Reproduction of Illustrations," Vol. VIII, p. 184; in particular p. 217.

Phrenology. A doctrine, advanced by Dr. Franz Joseph Gall, which maintains that the external configurations of the skull are indicative of certain mental characteristics. See "The New Science of Experimental Psychology," Vol. IV, p. 247.

Physical Diagnosis. A method of external examination, introduced by Corvissart, the physician to Napoleon, whereby diseased conditions are detected by certain mechanical methods of examination, such as "chest-tapping," etc. See "Nineteenth Century Medicine," Vol. IV, p. 199.

Physics. The science that deals with matter and its properties and with the transformations of energy. From this it will be seen that its scope is very wide and far-reaching. See "Galileo and the New Physics," Vol. II, p. 93; "Modern Theories of Heat and Light," Vol. III, p. 206; "The Conservation of Energy," Vol. III, p. 253; "The Ether and Ponderable Matter," Vol. III, p. 283; "The Royal Institution and Low-temperature Researches," Vol. V, p. 29; "Some Physical Laboratories and Physical Problems," Vol. V, p. 73; "Some Unsolved Scientific Problems," Vol. V, p. 203. Electricity (q.v.) is a department of Physics, and nearly all the appliances of the mechanical world fall within the scope of Applied Physics. See, for example, the chapter "How Work is Done," Vol. VI, p. 29.

Physiology. In a restricted sense it is applied to that department of inquiry which investigates the functions of living organisms, such as the functions of the brain, liver, etc. In a broader sense it covers the sum of all knowledge concerning living organisms. See "Anatomy and Physiology in the Eighteenth Century," Vol. IV, p. 73; and "Anatomy and Physiology in the Nineteenth Century," Vol. IV, p. 102.

Pigments. The name given to paints, or any preparations used by painters and dyers. Also, the coloring matter found in the tissues of most animals and plants. See "Paints, Dyes, and Varnishes," Vol. VIII, p. 258.

Piston Engine. A form of engine invented by Denis Papin about 1688. The name is still used to distinguish certain types of engines (such as the locomotive) from rotary engines, turbine engines, etc. See "Captive Molecules: The Story of the Steam Engine," Vol. VI, p. 79.

Pitch-blende. A heavy, black, pitchy-looking mineral, found principally in Saxony, Bohemia, Cornwall, and Colorado. It was while experimenting with this substance that M. Henri Becquerel discovered the so-called "Becquerel rays" in 1896. See "Radio-activity," Vol. V, p. 97.

Plagues. The name given to epidemics of various diseases which caused great loss of life during the middle ages and until quite recent times.

Polonium. An element discovered by Mme. Skoldowska Curie in 1898. Mme. Curie discovered it while examining the mineral pitch-blende (q.v.) and named it in honor of her native country, Poland. For chemical symbol and atomic weight, see "Element," in the present index.

Ponderable Matter. See "The Ether and Ponderable Matter," Vol. III, p. 283.

Power. In mechanics and physics, the application of energy through which work is performed; also, the rate at which work is performed—that is, the amount of work performed per unit of time. See "How Work is Done," Vol. VI, p. 29. The subject of power as generated by muscles, wind, water, steam, and electricity will be found in the chapters dealing especially with these subjects. See general index.

Predynastic Period. The period in Egyptian history antedating the historic period.

Printing. For the full account of the development of printing, see "The Printing and Making of Modern Books," Vol. VIII, p. 119. In the same volume are the chapters dealing with the closely allied subjects, "The Manufacture of Paper," p. 159; and "The Reproduction of Illustrations," p. 184.

Protoplasm. An albuminous elementary organic compound which enters into the composition of organized tissues of all kinds. See "The Cell Theory Elaborated," Vol. IV, p. 122.

Psychology. That branch of knowledge which deals with the mind. See "The New Science of Experimental Psychology," Vol. IV, p. 245.

Pulley. A wheel turning on a pin, having a groove on its circumference in which runs a rope for turning it. It is a form

of lever that was well known to the ancients, but Archimedes brought it to its highest state of perfection. See "Wheels and Pulleys," Vol. VI, p. 32.

Pump. A machine for raising liquids or extracting gases. The common form is the piston pump, but there are also centrifugal, rotary, electric pumps. For the invention of the air-pump, see "Mariotte and Von Guericke," Vol. II, p. 210. For the development of steam pumps, see "The Story of the Steam Engine," Vol. VI, p. 79. For pumps run by hot-air engines, see "Gas and Oil Engines," Vol. VI, p. 132. For electric pumps, see "Electric Mining Pumps," Vol. VI, p. 263.

Quadrant. An old form of sextant (q.v.).

Quinine. An alkaline substance obtained from the bark of trees of the cinchona genus. The bark of these trees was introduced as a medicine in 1640.

Rabies. A germ-produced disease affecting certain animals, especially dogs, from which hydrophobia is communicated. Pasteur discovered a preventive inoculation for this disease. See "Aims and Objects of the Pasteur Institute," Vol. V, p. 182.

Radio-activity. The property possessed by certain substances of spontaneously and continuously emitting penetrating rays capable of passing through bodies opaque to ordinary light. It was discovered by M. Henri Becquerel in 1896. See "Radio-activity," Vol. V, p. 97.

Radiolarians. Creatures of microscopic size found in the mud of the ocean bottom, etc. Prof. Ernst Hæckel discovered, named, and described more than 4,000 new species, obtained from a few ounces of mud. See "Ernst Hæckel and the New Zoology," Vol. V, p. 153.

Radium. A new element discovered by Professor and Mme. Curie in 1898, which possesses remarkable powers of radiation. See "Radio-activity," Vol. V, p. 97.

Refrigerator Machines. Mechanisms for producing very low temperatures, used for liquefying gases, such as hydrogen, air, etc. See "The Royal Institution and Low Temperature Researches," Vol. V, p. 38.

Respiration. The process of taking in oxygen and giving off carbon dioxide by the respiratory organs of animals. In man and the higher animals this function is performed by the lungs.

This fact was not established until late in the eighteenth century. See "The Function of Respiration," Vol. IV, p. 92.

Rhodium. A metal belonging to the platinum group, discovered by Wollaston in 1804. See "Element" in the present index for chemical symbol and atomic weight.

Rosetta Stone. A slab of black rock found in Egypt, the inscriptions on which furnished the key for the decipherment of the Egyptian hieroglyphics. It was discovered in Egypt in 1799, and is now in the British Museum. See "The New Science of Oriental Archæology," Vol. IV, p. 287.

Rotary Engine. A type of engine in which rotary motion is obtained direct, without change of direction as in the case of reciprocating engines. The turbine engine is an example of a rotary steam engine. See "Rotary Engines," Vol. VI, p. 119.

Ruby. A precious stone, rich red in color, a transparent variety of corundum. It can be produced artificially of considerable size. See "Gems, Natural and Artificial," Vol. IX, p. 319.

Saliva. A liquid secreted by the salivary glands of the mouth, containing a digestive ferment. See "Animal Chemistry," Vol. IV, p. 128.

Sarcode. The name given by Dujardin to the viscid, slimy fluid, capable of motion, found within the cell wall. See "The Cell Theory Elaborated," Vol. IV, p. 122.

Scandium. One of three then unknown elements, the existence of which were predicted by Mendeleeff on formulating his periodic law. See "Periodicity of Atomic Weights," Vol. IV, p. 64.

Serum-therapy. A method of treating certain diseases by means of the modified blood serum of man or the lower animals. Behring's diphtheria antitoxine serum, discovered in 1892, is an example. See "Preventive Inoculation," Vol. IV, p. 231, and "Serum-therapy," Vol. IV, p. 240; also, "Aims and Objects of the Pasteur Institute," Vol. V, p. 182.

Sextant. A portable instrument for measuring the altitudes of heavenly bodies above the horizon, or their angular distance as seen in the sky; hence its use with the chronometer in determining exact latitude and longitude. See "The Development of the Sextant," Vol. VII, p. 18.

Shooting-stars. See Meteorites.

Signatures, Doctrine of. A mediæval theory, which in effect

matter. See Vol. IV, p. 180; also, "Pasteur and the Germ Theory of Disease," Vol. IV, p. 217; also, "Life Problems," Vol. V, p. 220.

Static Machine. A machine for generating static, or frictional, electricity. It consists of a large circle of glass so arranged that its surface can be revolved rapidly against a suitable friction producer. Until the beginning of the nineteenth century static machines were the only kind of apparatus known for generating electricity. See "Progress in Electricity from Gilbert and Von Guericke to Franklin," Vol. II, p. 259.

Statics. The science that deals with stationary bodies in equilibrium or under conditions of stress or strain.

Steam. Water in a gaseous state. Water becomes gaseous at sea-level at a temperature of 212°F., or 100°C.

Steamboat. See "Steam Engine" of the present index, and in particular "The Highway of the Waters," Vol. VII, p. 56.

Steam Engine. For the story of the development of the steam engine, see "Ctesibus and Hero: Magicians of Alexandria," Vol. I, p. 242; "Captive Molecules: The Story of the Steam Engine," Vol. VI, p. 79; "The Master Worker," Vol. VI, p. 110. For the application of steam in various fields, see "The Highway of the Waters," Vol. VII, p. 56; "The Steam Locomotive," Vol. VII, p. 119; "From Cart to Automobile," Vol. VII, p. 152.

Steam Locomotive. See "Locomotive" of the present index.

Steel. Is an alloy of iron and carbon; or a modified form of iron containing more carbon than wrought-iron and not as much as cast-iron, as a rule, although some mild steels contain as little carbon as wrought-iron. See "The Age of Steel," Vol. VI, p. 271.

Steelyard. An old-fashioned and primitive form of balance for weighing objects. The principle upon which the steelyard works is that of a lever of the first class.

Stethoscope. An instrument for listening to the sounds of the internal organs, particularly the lungs and heart. It consists essentially of a hollow tube, funnel-haped, which collects and concentrates the sound waves, just reversing the action of the megaphone. It was invented by Lænnec, a French physician, in 1815. See Vol. IV, p. 201.

Storage Battery. An electric battery for collecting and storing electricity. For the recent improvement in storage batteries, including the invention of Thomas A. Edison, see "Storage Battery Systems," Vol. VII, p. 188.

tant objects appear near, the invention of the Dutch optician Lippershey in the seventeenth century. In 1609 Galileo invented another type of telescope for astronomical observations. See Vol. II, p. 77. For later improvements in telescopes, see "Instruments of Precision in the Age of Newton," Vol. II, p. 252.

Telluric Structure. Pertaining to the structure of the earth. See "Solar and Telluric Problems," Vol. V, p. 205.

Telpherage Systems. The invention of Fleeming Jenkin, which consists of overhead cables hung on poles along which carriers of small capacity are hauled by electric motors. See "Traction in Mining," Vol. VI, p. 256.

Tetanus. The disease commonly known as lockjaw, is characterized by spasm of the voluntary muscles. It is caused by the tetanus bacillus, which was discovered by Nicolaier in 1884. Behring discovered an antitoxic serum which averts the attack of the disease when administered in time. See "Serum-therapy," Vol. IV, p. 240.

Textiles. Materials made by weaving together of threads to form a nearly solid surface, such as cloth, rugs, etc. The term does not apply to substances woven of wood, such as baskets. See "The Manufacture of Textiles," Vol. IX, p. 38.

Thermometer. A familiar instrument for determining the temperature. The most common form is that of an exhausted closed glass tube in which a column of mercury expands and contracts. The two kinds in more common use are the Centigrade, the freezing point of which is 0, and the boiling point 100; and the Farenheit, the freezing point of which is 32°, the boiling point 212°.

Thorium. An element discovered by the Swedish chemist Berzelius, and named by him after the ancient Scandinavian god Thor. It is one of the most valuable of the rare elements. The oxide of thorium is used in the preparation of gas mantles. See "The Incandescent Gas Mantle," Vol. VI, p. 208.

Toxine. Substances, generally of bacterial origin, which, when brought into the circulation, produce diseases of a distinct nature according to the nature of toxine. See "Serum-therapy," Vol. IV, p. 240.

Transformers. In electricity, are mechanisms for transforming a current of a certain voltage into one of higher or lower voltage. A "step-up" transformer changes a current of low voltage to one of higher voltage; a "step-down" transformer acts

Undulatory Theory of Light. According to this theory light is a kind of undulatory motion produced by the luminous body in the particles of an elastic, imponderable medium called the luminiferous ether, which is supposed to fill all space, and also the interstices of all bodies. See "Thomas Young and the Wave Theory of Light," Vol. III, p. 215.

Uranium. A metallic chemical element discovered by Klaproth in 1789, and first isolated by Peligot in 1842. Its atomic weight is 238.5, specific gravity 18.6, symbol U.

Valence (valency). The combination value or capacity of a chemical atom, in virtue of which it can unite with one only or with more than one atom equivalent to the hydrogen atom. See "Chemical Affinity," Vol. IV, p. 57.

Valves of the Veins. Structures in the lumen of veins which prevent the flow of blood backward away from the heart. They were discovered and described by the French anatomist, Charles Etienne (1503-1564). See Vol. II, p. 166.

Varnish. A solution of certain resins, such as mastic, lac, copel, asphalt, amber, benzoin, etc., capable of hardening without losing its transparency. Ordinary commercial varnish is a solution of resin in oil of turpentine. See "Varnishes," Vol. VIII, p. 316.

Vitagraph. A moving-picture machine similar to the kinetoscope, patented by Thos. A. Edison in 1891. See "Chronophotography—Moving Pictures," Vol. VIII, p. 248.

Vitalists. Followers of a system of medicine championed by Paul Joseph Barthez in the eighteenth century. They assumed that there was a "vital principle," of unknown nature, but differing from the thinking mind, or the soul, which was the cause of all the phenomena of life. See "Animists, Vitalists, and Organicists," Vol. IV, p. 184.

Vitascope. See "Vitagraph" of the present index.

Volt. The unit of electro-motive force. See "Electricity" of the present index.

Vortex Atom. See "Vortex Theory."

Vortex Theory. A conception that the atoms and molecules of physical science may be vortex rings or filaments, or combinations of these, in the universal ether. See "Physical Problems," Vol. V, p. 213.

wheel is a lever of the first class, of which the axle constitutes the fulcrum. See "Wheels and Pulleys," Vol. VI, p. 32.

Windlass. A modification of the wheel and axle, consisting of a cylinder rotating on an axis propelled by a long handle, or handles, a rope or chain being wound about the cylinder. It is a lever of the second class, the axle representing the fulcrum.

Windmills. Machines utilizing the pressure of the wind as a motive power. The usual type of windmill consists of a series of inclined planes, each of which forms one of the radii of a circle, or spokes of a wheel, to the axle of which a gearing is adjusted by which the power generated is utilized. Windmills seem to be of comparatively recent origin, as there is no authentic record of their use prior to about 1100 A.D. See "The Work of Air and Water," Vol. VI, p. 62.

Wind. Air naturally in motion at the earth's surface. All winds come under the influence of the earth's rotation in such a way as to be deflected from their course, and hence take on a gyratory motion. See Vol. III, p. 200.

Wireless Telegraph. In the modern sense, an electric telegraph which utilizes electro-magnetic waves ("Hertzian waves") in the ether in place of wire, or other conductors, for sending and receiving messages. There are several other methods of using the electric current besides this, but none that are effective for long distances. See "Wireless Telegraphy," Vol. VIII, p. 47.

Wireless Telephone. A telephone which utilizes Hertzian waves in the ether in place of wire conductors of the electric current. The first practical wireless telephone system was the invention of Dr. Lee DeForest, an American, which was exhibited publicly in 1907. See "The Wireless Telephone," Vol. VIII, p. 88.

BIOGRAPHICAL INDEX

(The matter under this alphabet constitutes at once a Biographical Reference Index and a condensed Biographical Dictionary of the Important names in every department of science. The figures following the names refer to the text by volume and page. The reading matter is complementary to the matter of the Technical Index and Glossary, and of the General Index, and to some extent supplementary of the text itself.)

Abd-el-Letif, or Abd-ul-Latif, ii, 21. Born at Bagdad, 1162; died at Bagdad, 1231. Arabian scholar and author of multifarious acquirements. He labored unceasingly in his early years to acquire all the knowledge of his age. Lived at Damascus and spent many years in Egypt, of which country he has left an excellent and accurate account. Devoted much time to study of medicine.

Adams, John Couch, iii, 42, 48. Born at Cornwall, England, 1819; died at Cambridge, 1892. At an early age he displayed a great aptitude for mathematics and became a mathematical tutor at Cambridge. In 1841 he set himself to the task of discovering the cause of the irregularities in the motion of the planet Uranus, and in October, 1844, wrote an account of the existence of a new planet and gave its location. This, unfortunately, he did not publish. Leverrier, in France, took up the same subject in 1845, and announced the existence of Neptune in November of that year. Hence he obtained the whole honor of the discovery, which Adams should have shared. In 1858 Adams was appointed professor of mathematics at St. Andrews, Cam-

Born at Mesopotamia cir. 850; died, 929. The greatest of Arabian astronomers, who discovered the motion of the sun. Made observations steadily for over 60 years at the Euphrates and at Antioch in Syria. Wrote "The Science of the Stars." Improved Ptolemy's table and came very close to ascertaining the obliquity of the ecliptic. His observations were the foundations of the Alphonsine table of the Moon's motion.

Albertus Magnus (Albert Count of Bollstädt), ii, 127. Born at Swabia, 1193 or 1205 (accounts vary); died at Cologne, 1280. Became Dominican friar after studying at Padua, and taught in many places. Went to Paris 1230, and devoted himself to spreading the doctrine of Aristotle in spite of the prohibition of the Church. In 1260 was made Bishop of Ratisbon. 1262 retired to a convent at Cologne and devoted rest of life to literary pursuits.

Albucasis (or Albucasim), ii, 25. Born near Cordova, Spain; died, 1106. Famous Arabic physician and author of "Al-Tasrif," a medical encyclopædia, containing the best treatise on surgery that has come to us from antiquity.

Alcmaèon, i, 126. Born at Crotona, Italy, second half of Sixth Century B.C. Greek physician and naturalist. Was the first man to practice dissection, by which he made many valuable discoveries in anatomy. Author of "On Nature."

Alfonso X, ii, 17. Born in 1221; died in 1284. King of Leon and Castile. Most learned prince of his time. The chief debt of science to him is the Alfonsine Tables, which he had compiled by fifty of the most celebrated astronomers of

dualistic theory was further developed by Plato and Aristotle. He was banished from Athens for the impiety of his explanation of natural phenomena. He may have been guilty of disrespect for the gods, but he came very near to being right in his explanation of the causes of the rainbow, the Moon's light, the winds, and the origin of sound. He died a wanderer in exile.

Anaximander, i, 109. Born at Miletus, 610 B.C.; died in 546 B.C. Successor of Thales as head of the Ionian School; was a great mathematician and astronomer, as well as philosopher. Taught the obliquity of the ecliptic, and introduced the sun-dial into Greece. It is believed that he invented geographical maps. Conceived the universe as a series of concentric cylinders. As a philosopher he believed the phenomenal world to proceed from some indefinite or indeterminate principle, similar, perhaps, to the chaos of other philosophers. There was no such thing as creation out of nothing, but the atoms of primary matter change their relative positions through some innate power and become the contents of the phenomenal world.

Anaximenes, i, 109. Born at Miletus, flourished Sixth Century, B.C. He taught that air was the primary form of matter, and that all things were formed from it by compression.

Arago, Dominique François, iii, 67. Born at Estagel, France, 1786; died at Paris, 1853. French physicist and astronomer. Became professor of analytical geometry and geodesy at the École Polytechnique, Paris, but afterward devoted more attention to astronomy, electricity,

galvanism and the polarization of light. He proved the value of the undulatory theory of light. He continued Oersted's discoveries in electromagnetism, by showing that an unmagnetized bar of steel or iron could be magnetized by a voltaic current. He also showed the fact of magnetization by rotation.

Archimedes, i, 196. Born cir. 287 B.C.; killed at capture of Syracuse, 212 B.C. Syracusan mathematician, the most famous of all antiquity. Developed pure geometry, and applied mathematical theories to mechanics. Invented hydraulic screw, and is given credit for explaining principle of lever. Constructed catapults and other engines which delayed the fall of Syracuse (212 B.C.).

Aristarchus of Samos, i, 212. Lived first half Third Century, B.C. Alexandrian astronomer. Made many observations of which we know only a few. He calculated the relative distances of sun and moon from earth. His theory of calculation was correct, but inaccurate in practice. It is said that with the Pythagoreans he believed the earth to revolve around the sun.

Aristotle, i, 82. Born at Stagira, 384 B.C.; died at Chalcis, 322 B.C. Greek philosopher and scientist. After living in various places and teaching, he settled at Athens and opened the so-called peripatetic school. As a scientist he treated of astronomy, zoology, mechanics and physics at considerable length. His two chief mental faculties were great aptitude for observation, and a logical method, which lay in the assiduous collection of facts, and the drawing of inductions from them. In this he com-

pletely discarded the pre-existing "ideas" or "forms" of Plato. His "System of Logic" is the basis of that used at the present day. He was for three years the tutor of Alexander the Great.

Arkwright, Sir Richard, ix, 17. Born at Preston, England, Dec. 23, 1732; died at Cromford, Derbyshire, England, Aug. 3, 1792. Invented the cotton-spinning frame, or "waterframe," a device that revolutionized spinning. He began life as a barber, and his early inventions were made in leisure hours when not working at his trade. He amassed an enormous fortune as a result of his invention, and in 1786 was knighted by George III.

Arnold of Villanova, ii, 34. Born cir. 1240; died in 1313. Nationality unknown. A physician, alchemist, and astrologer, who taught at Paris, Barcelona, and Montpellier. He has been incorrectly credited with the discovery of hydrochloric, nitric, and sulphuric acids. These were certainly known before his time.

Arrhenius, Svante. Born at Upsala, 1859. Swedish physical chemist, professor in the University of Stockholm. His theory of electrolytic dissociation, which he has established, is one of the most important of recent contributions to science. It is that if a current is passed through a substance whose aqueous solution is capable of conducting electricity, it is broken up in solution into parts of the composing elements charged, some with positive and others with negative electricity. The existence of positive and negative "ions" has explained a number of chemical phenomena hitherto incomprehensible.

Arzachel, ii, 16. Born in Spain, cir. 1050.

Bacon, Francis, ii, 192. Born at London, 1561; died at Highgate, 1626. English philosopher and statesman. Educated at Cambridge, was attached to Embassy in France, 1576. Entered Parliament, 1584. Knighted, 1603; held many political offices up to Lord Chancellor, 1618, and tried for bribery, removed and fined, 1621. He was a great reformer of methods of scientific investigation, and one of the chief founders of modern inductive science. Chief works, "Novum Organum" and "Advancement of Learning."

Bacon, Roger, ii, 44. Born at Ilchester, cir. 1214; died at Oxford (probably) 1294. English monk and philosopher. Studied at Oxford, Paris, returned to England and entered Franciscan order at Oxford, where he carried on researches in alchemy and optics. Was removed to Paris, 1257, after having been accused of unorthodoxy and dealing with the black art. All writing materials and instruments were taken from him. Despite the Franciscan prohibition, he prepared his "Opus Majus" at the request of Pope Clement IV. This was an encyclopædia of all the science and knowledge of the time. Ten years after Clement's death he was free to do as he liked, but was imprisoned again by Pope Nicholas III, and his books forbidden to be read. He had found out much in the way of chemistry and by some is credited with knowing of the existence of gunpowder. He studied much in optics and corrected many errors in the calendar.

Baglivi, Giorgio, iv, 182. Born at Ragusa, Sicily, 1669; died at Rome, 1707. Italian physician

of Armenian extraction. Went to Rome and was appointed Professor of Anatomy at the College di Sapienza. He was the first to propound the medical doctrine of "solidism," according to which the primary seat of disease is in the solid parts of the organism, and not in the fluid, as was believed up to that time.

Bastian, Henry Charlton, iv, 180. Born at Cornwall, 1837. English physician and biologist. Professor in University College, London. Noted nerve specialist. Strong defender of the doctrine of spontaneous generation.

Becquerel, Alexandre Edmond, viii, 235. Born at Paris, 1820; died at Paris, 1891. French physicist, son of Antoine César. Member of Academy of Science, 1863. In 1878 succeeded his father as Professor of Physics at the Conservatoire des Arts et Métiers. Researches in electricity, optics and photography. Well known for his work on the Solar spectrum.

Becquerel, Antoine Henri, v, 98. Born at Paris, 1852; died at Paris, 1908. French physicist, Professor of Physics in the École Polytechnique, Paris. His researches have been mainly concerned with optics, chiefly the invisible radiation from uranium, known as the Becquerel rays.

Behring, Emil Adolf, iv, 242. Born at Hansdorf, Prussia, 1854. German physician who in 1895 became director of the Hygienic Institute at Marburg. Most noted for his discovery of diphtheria serum. He made a special study of the question of immunity from disease.

Barthez, Paul Joseph, iv, 185. Born at Montpellier, 1734; died at Paris, 1806. French physician. Became Professor of Medicine Montpel-

lier University, 1761. He formulated a new theory of life—that of a vital principle in the living organism, which is different from both the thinking mind and the physical forces of the body. The life of each separate organ is a particular manifestation of the vital principle. He made no experiments to substantiate his views.

Bell, Alexander Graham, viii, 73. Born at Edinburgh, 1847. American inventor and scientist. Educated in Great Britain, came to Canada, 1870. He became greatly interested in his father's system of instruction for the deaf and dumb, and after his appointment as Professor of Vocal Physiology at Boston University, 1872, began the experiments which led to the invention of the telephone. Has also invented the photophone, which transmits sounds by waves of light; also the graphophone.

Bell, Alexander Melville, viii, 78. Born at Edinburgh, 1819. Scottish-American educator. After teaching at Edinburgh and London Universities came to Queen's College, Kingston, Canada, and later, 1881, removed to Washington, D. C. Inventor of the visible-speech system for teaching deaf-mutes to speak.

Bell, Sir Charles, iv, 249. Born at Edinburgh, 1-774; died in 1842. Scottish surgeon, anatomist and physiologist. In early life practiced and lectured Edinburgh and London. Made a special study of gunshot wounds during the Napoleonic wars. 1826 became head of medical department, London University. His principal work and practice was in connection with nervous diseases, upon which he was a great authority.

Bernard, Claude, iv, 137. Born at St. Julien, 1813; died at Paris, 1878. French physiologist. Educated in Paris, he succeeded Magendie as Professor of Experimental Physiology at the Collège de France, 1855, having been chosen for the Academy of Science the previous year. Founded the Société de Biologie, and was its president from 1867. His most distinguished work was in connection with the secretions of the alimentary canal, and the action of the nervous system on them. He was the first to show that the pancreatic juice was the true agent of the digestion of fatty substances. When he died his funeral was conducted at the public expense, an honor never before given to a man of science.

Berosus, i, 58. Lived and wrote first half of Third Century, B.C. Greek historian, a priest of Belus at Babylon. Wrote three books on Babylonian history, which are of interest for their agreement with the early Hebrew records.

Berthelot, Pierre Eugène Marcellin. Born at Paris, 1827; died at Paris, 1907. French chemist, educated in Paris, and devoted his life to research in organic chemistry. His first achievements attained in 1854, when he gave his account of the artificial reproduction of natural fats, a matter which has since been of great importance to industry. In 1865 a chair was created for him at the Collège de France. In later years he materially increased our knowledge of every class of carbon compound, and made important experiments with explosives and aniline dye-stuffs. In 1889 was perpetual secretary of the Academy of Science. Has also taken an interest in politics.

1881 created lifelong member of Senate. 1886-1887, Minister Public Affairs. 1895-1896, Minister Foreign Affairs.

Berthollet, Count Claude Louis, iv, 41. Born at Savoy, 1748; died at Paris, 1822. French theoretical chemist. After graduation from Turin University went to Paris as physician to Duke of Orleans. Applied himself to chemistry, working out the theories of Lavoisier and Priestly. Was the first to discover the composition of ammonia. In 1794 was made professor at the École Normale. His visit to Egypt with Napoleon's expedition led to the foundation of the Institute of Cairo. With Lavoisier, he devised the system of chemical nomenclature still in the main employed.

Berzelius, Johan Jakob, iv, 41. Born at Westerlosa, Sweden, 1779; died at Stockholm, 1848. Swedish chemist. After graduation at Upsala, devoted himself to chemistry. 1807 became Professor of Medicine and Pharmacy at Stockholm. Accomplished a prodigious amount of work in chemistry. His discoveries and views gave a firm foundation to inorganic chemistry. He established the laws of combination. Famous for his analyses and discoveries (including several elements) with the blow-pipe. Interest in his theory, that chemical combination was the result of electrical attraction, although abandoned for many years, has recently been revived owing to the researches of his famous fellow-countryman, Arrhenius, although considerable modification of it is necessary.

Bessel, Friedrich Wilhelm, iii, 42. Born at Minden, 1784; died at Königsberg, 1846. Ger-

man astronomer; has been called with some reason the father of modern observational astronomy. Became astronomer in opposition to his parents' wishes, and in 1810 was Professor of Astronomy and Observatory Director at Königsberg. He determined the parallax of 61 Cyngi, and made the first measurement of distance of a star from the solar system. He was one of the first to consider the personal equation of astronomers.

Bessemer, Sir Henry, vi, 291. Born at Charlton, England, 1813; died in 1898. English inventor. He turned his attention at an early age to mechanical inventions. Devised a method of impressing stamp of internal revenue office in order to prevent forgeries. Made a gold paint which was very successful commercially. During Crimean War turned his attention to making stronger cannon. He first produced an improved form of cast-iron, and finally steel by bringing air into contact with molten iron. The Bessemer process had a marked effect in cheapening cost of steel, and making it available for all kinds of engineering work. Invented also a method of compounding graphite into a solid block for pencil making, a method of type-casting, and several other processes.

Bichat, Marie François, iv, 107. Born at Thoirette, 1771; died at Paris, 1802. French anatomist and physiologist. Ended his brilliant career at an early age through overwork. He lectured on anatomy and was physician in the Hotel Dieu, Paris. He was the founder of the science of pathological anatomy, and was the first to

show that the different organisms have membranes and tissues in common.

Biot, Jean Baptiste, iii, 168. Born at Paris, 1774; died at Paris, 1862. French physician and astronomer. Forsook the army for science. 1880 became Professor of Physics in the Collège de France. Assisted in measuring the arc of the meridian as the basis for the metric system. Associated with Arago in many of his experiments, and with Gay-Lussac made the first balloon ascension for scientific purposes. Made valuable contributions with regard to polarization of light.

Birch, Samuel, i, 27. Born at London, 1813; died at London, 1885. English archæologist. Keeper of Oriental antiquities in the British Museum. Made a special study of the Egyptian hieroglyphics.

Black, Joseph, iv, 12. Born at Bordeaux, France, 1728; died at Edinburgh, 1799. Scottish chemist. In 1754 took his degree in medicine at Edinburgh. Was professor of anatomy and Lecturer on Chemistry at Glasgow. 1766 was made Professor of Chemistry at Edinburgh. He first clearly established the existence of carbonic acid gas, and evolved the theory of latent heat, which opened the way for Watt's improvements in the steam-engine.

Bond, William Cranch, iii, 44. Born at Portland, Me., 1789; died at Cambridge, Mass., 1859. A self-educated American astronomer who attracted much attention by his discoveries at his private observatory, Dorchester, Mass. Supervised the construction of Harvard Observatory and became its director. Invented a method of

after 1738 Professor of Physics in the University of Wittenberg. At the bombardment of that city, 1760, he was taken as hostage by the Prussians to Magdeburg, where he died the following year. Made researches and wrote on astronomy, physics, and electricity.

Boyle, Robert, ii, 205. Born at Waterford, Ireland, 1627; died at London, 1691. Irish physicist and chemist. Studied at Eton and on the Continent. Devoted himself to science. One of the originators of the Royal Society. In 1654 settled at Oxford and experimented in pneumatics, improving the air-pump. Was very active in religion. Formulated independently of Mariotte the law of gases known by his name. Succeeded Bacon in the reputation of being the greatest English scientist of his time.

Bradley, James, iii, 13. Born at Sherborne, England, 1693; died at Chalford, 1762. English astronomer. Educated at Oxford. 1721 appointed to Savilian Chair of Astronomy, Oxford. 1729 announced discovery of aberration of light. 1742 appointed Astronomer Royal and made many important discoveries at Greenwich, among them nutation of the earth's axis. By procuring new instruments, he made the Royal Observatory the first of the great modern observatories. Newton called him "the best astronomer in Europe."

Brahe, Tycho, i, 217. Born at Knudstrup, Sweden, 1546; died at Prague, 1601. Danish astronomer, educated at Copenhagen. Destined for law, but persisted in studying astronomy, in which he made many discoveries. 1572 discovered a new and brilliant star in Cassiopeia.

anthropologist. Studied in Paris, and taught there in several places. In 1847 began a thorough study of anthropology. 1859 founded the Anthropological Society of Paris. 1876 founded the Ecole d'Anthropologie, now the Anthropological Institute. Made many valuable contributions to anthropology. In 1861 he discovered the location of the seat of articulate speech in the brain.

Brown, Robert, iv, 115. Born at Montrose, Scotland, 1773; died at London, 1858. Scotch botanist. Educated Aberdeen and Edinburgh. Entered British Army as assistant-surgeon. Resigned commission, 1800, to study botany. Went to Australia and brought back over 4,000 specimens of plants, most of them new to science. Adopted the Jussien natural system and helped in its general substitution for that of Linnæus. In 1810 took charge of the Bank's collection, which was afterward transferred to British Museum, where he became keeper of the botanical department.

Brush, Charles Francis, vi, 226. Born at Euclid, Ohio, March 17, 1849. His inventions are largely responsible for modern arc-lighting systems. In 1881 the French Government decorated him for his work in electricity, and in 1900 the American Academy of Arts and Sciences awarded him the Rumford medal.

Brugsch, Hermann Karl, i, 28, iv, 187. Born at Berlin, 1827; died at Berlin, 1894. German Egyptologist. Visited Egypt several times for archæological purposes. Professor at Göttingen University. Director of the Egyptological School at Cairo. 1881, succeeded Mariette as

himself especially to zoology and chemistry. Studied also at Paris, Berlin, and Vienna. Taught various places, and finally appointed, 1852, Professor of Chemistry, at Heidelberg. Invented the magnesium light, 1860. He and Kirchoff discovered spectrum analysis, which have been the means of great advances in astronomy and chemistry.

Burnham, S. W., iii, 59. Born at Thetford, Vermont, 1838. American astronomer. A stenographer by profession, he became interested in astronomy and made a special study of double stars, of which he has recorded over twelve hundred, his powers of observation being very extraordinary. Professor of Practical Astronomy, University of Chicago.

Calmette, Léon Charles, v, 184. Born at Nice, 1863. French bacteriologist. Has made many investigations especially relating to serum poisoning at the Pasteur Institute, Paris. Also investigations in tuberculosis. Has established Pasteur and anti-tuberculosis institutions in various parts of the world.

Calvin, John, ii, 168. Born at Noyon, Picardy, 1509; died at Geneva, 1564. French religious reformer. Studied at Paris, Orleans, and Bourges. Joined the Reformation about 1528. After various vicissitudes, settled at Geneva, when he finally assisted in establishing a theocratic government and preached religious doctrine, which, while severe, had great influence in the history of the Protestant religion.

Canton, John, ii, 295. Born at Stroud, England, 1718; died at London, 1772. English physicist. He made the discovery almost simul-

"Causes of Kinetic Energy," in which he described an apparatus for forcing up water by a steam fountain. For this Arago claimed for de Caus the invention of the steam-engine.

Cavendish, Henry, iv, 15. Born at Nice, 1731; died at London, 1810. English physicist and chemist. Educated at Cambridge, devoted his entire life to science, and having inherited considerable means, remained unmarried and lived the life of a recluse. Discovered composition of water and devised a method for determining density of earth. Made many investigations of properties of carbonic acid gas.

Celsius, Anders, vi, 14. Born at Upsala, 1701; died at Upsala, 1744. Swedish astronomer. Professor at Upsala. Took part in the French expedition, 1737, to measure a degree of the meridian in the polar regions. Presented the first idea of the centigrade thermometer.

Celsus, Aulus Cornelius, ii, 40. Probably lived in the reign of Tiberius. Latin physician. Introduced the Hippocratic systems among the Romans. Wrote on other subjects besides medicine. His writings on surgery are especially valuable, and contain much about the work and opinions of the Alexandrian School.

Chabas, François Joseph, i, 28. Born at Briançon, 1817; died at Versailles, 1882. French Egyptologist, although engaged throughout life in business as a wine merchant. Declined a chair in the Collège de France. Became a leading authority on the ancient Egyptian language and translated many of the hieroglyphic and hieratic writings.

Chambers, Robert, iv, 162. Born at Peebles,

cian. Son of a farmer, he taught himself engraving. Began to manufacture telescopes in 1844. Was the first to make achromatic lenses in the United States. The lenses of most of the great telescopes of recent times were ground at the establishment he founded for such purposes at Cambridge, Mass.

Clausius, Rudolf Julius Emanuel, vi, 115. Born at Koslin, Prussia, 1822; died at Bonn, 1888. German physicist who made a special study of thermo-dynamics.

Colding, Ludwig August, iii, 257. Born at Arnakke, Denmark, 1815. Danish engineer and meteorologist. Studied at Copenhagen and became professor there. Made special investigations of tropical cyclones.

Columbus, Christopher, ii, 50. Born near Genoa, Italy, cir. 1446; died at Valladolid, Spain, 1506. Italian explorer. Started his career in the wool-trade. Probably first went to sea about 1473, and lived in Lisbon until 1485, engaged in map-making, and seafaring, one voyage, 1477, taking him to Iceland. Convinced of the feasibility of reaching the spice-countries of Asia by a westward route, he sought financial assistance from Venice and Portugal without avail. Finally Queen Isabella became interested. An expedition was fitted out, and Columbus reached the West Indies (probably Watlings Island), October 12, 1492.

Cope, Professor Edward Drinker, iii, 113. Born at Philadelphia, 1840; died at Philadelphia, 1897. American naturalist. Studied medicine. Was Professor of Natural Science, Haverford College, afterward Professor of Geology, Uni-

versity of Pennsylvania. Made a special study of extinct vertebrates. He belonged to that school of evolutionists who believed that the variations caused by environment are inherited by offspring, and upholding these views, became involved in much controversy.

Copernicus, Nicolaus, ii, 54. Born at Thorn, Prussia, 1473; died at Frauenburg, 1543. German astronomer. Studied mathematics and other sciences at Cracow, afterward in Italy. Appointed Professor of Mathematics at Rome, 1500. 1505, returned to Germany, took holy orders and obtained canonry at Frauenburg. 1530, completed his great work "De Revolutionibus Orbium," which described the true system of the sun, stars and planets. This he did not publish until twelve years later, probably through fear of ecclesiastical censure.

Corvisart, Jean Nicolas de, iv, 199. Born at Drecourt, France, 1755; died at Paris, 1821. French physician. His father destined him for the law, but he ran away to Paris, and concealed himself in order to study medicine. 1786, became professor at La Charité Hospital, Paris. Later on Collège de France. Member Academy of Sciences. Was first physician to Napoleon I. Made valuable contributions to pathological anatomy regarding diseases of the heart.

Croll, Dr. James, iii, 197. Born at Whitefield, 1821; died in 1890. Scottish geologist. Had but little schooling, but made many valuable contributions of geological science, especially in regard to climatic changes during the glacial period, and their origin. Published theories as to origin of sun's heat and formation of stars

and nebulæ, which, though widely accepted, aroused much discussion. Was an officer of the Geological Survey of Scotland.

Crompton, Samuel, ix, 32. Born at Firwood, near Bolton, England, Dec. 3, 1753; died at Hall-in-the-Wood, near Bolton, June 26, 1827. An English mechanic and inventor. In 1779 he invented the "Mule," a spinning machine vastly superior to any machine then in use.

Crookes, Sir William, iii, 249, v, 103. Born at London, 1832. English physicist and chemist. Studied and taught at Royal College of Chemistry, Oxford, and Chester. Famous sanitary expert. His experiments with high vacua made the incandescent light possible. Discoverer of the element thallium, also the sodium amalgamation process for separating gold and silver from their ores. Devised new method of spectrum analysis for which the radiometer and otheoscope were invented.

Ctesbius, i, 243. Born at Alexandria; lived Third Century B.C. Greek mathematician, and tutor of Hero. Probably inventor of the force pump, and discoverer of the elastic force of air, with its possible application as motive power, all of which has been described by Hero.

Cunard, Sir Samuel, vii, 74. Born at Halifax, Nova Scotia, 1787; died at London, April 28, 1865. A civil engineer, founder of the Cunard Steamship Line. The first ship of this line, the "Britannia," crossed the ocean in 1840.

Curie, Professor Pierre, v, 100. Born at Paris, 1859; died at Paris, 1906. French physicist. Educated at Paris, became Professor of Physics at the Sorbonne, 1895. Noted for his researches

in radio-activity. In conjunction with his wife he discovered radium. The discovery was suggested by the fact that the Becquerel rays were analogous to the Röntgen rays, and that pitchblende possessed a high degree of radio-activity. By careful analysis M. and Mme. Curie extracted minute quantities of radium bromide in 1903, which feat seems likely to lead to extraordinary results in physics.

Curie, Madame Skaldowska, v, 100. Born at Warsaw, 1867. French scientist. Professor in the Faculty of Sciences, Paris. Wife of Prof. Pierre Curie, and associated with him in his researches.

Cuvier, Georges Baron de, iv, 159. Born at Montbéliard, France, 1769; died at Paris, 1832. French naturalist. Educated at Stuttgart for the Calvinistic ministry, in which faith he was strictly brought up. His great bent for natural history caused his father to abandon the plans for his future. Went to Paris and became Professor of Natural History successively at the Museum of Natural History, Ecole Centrale des Panthéon and Collège de France. 1802, succeeded Mertrud at the Jardin des Plantes. Devoted his life to paleontology, systematic zoology, and comparative anatomy, of which last science he was the founder.

Daguerre, Louis J. M., iv, 70. Born at Cormeilles, France, 1789; died near Paris, 1851. French physicist and painter. Began life as scene painter and evolved the Diorama. Together with Nicéphore de Nièpce in 1829, he began investigations in photography, and devised the means of photographing on a metallic

plate, from which all modern photography has developed. The daguerreotype was announced in 1839.

D'Alembert, Jean le Rond, iii, 15. Born at Paris, 1717; died at Paris, 1783. French mathematician and philosopher. Educated at the College Mazarin, and after trying law and medicine, devoted himself to mathematical science. Announced his famous principle of the equality of impressed and effective forces, 1743. Made many astronomical and mathematical solutions. 1751, with Diderot undertook editorship of the Encyclopédie. Withdrew in 1758. Had offers from foreign rulers which he did not accept.

Daniell, John Frederick, iii, 236. Born at London, 1790; died at London, 1845. English physicist who gave special attention to chemistry and meteorology. Professor of Chemistry, Kings College, London, 1831. Established, with Professor Brande, the "Quarterly Journal of Science and Art," 1816. Invented the hygrometer about 1820.

Dalton, John, iv, 40. Born at Eaglesfield, England, 1766; died at Manchester, 1844. English chemist. 1793 was made Professor of Mathematics and Physical Science at Manchester. He developed the atomic theory in chemistry, which revolutionized the science. In physics he experimented with the force of steam and electricity and expansive force of gases. Was held in the highest distinction and was the recipient of many honors. Was color-blind, and gave scientific description of this malady, which is often called Daltonism.

Dana, James Dwight, iii, 162. Born at Utica,

New York; died at New Haven, 1895. American geologist. Educated at Yale College. Appointed instructor U. S. Navy, afterward Professor Natural History at Yale (1855-1890). Member Wilkes exploring expedition (1838-1842), when he collected an immense amount of zoological material, on which he worked for thirteen years. Made valuable contributions to geology and mineralogy, and was honored by many scientific societies in Europe and America.

 Born at Shrewsbury, England, Feb. 12, 1809; died at Down, Kent, April 19, 1882. English naturalist, the greatest of the Nineteenth Century. Educated Edinburgh and Cambridge, destined for the church, but his tendencies were strongly toward natural history. Went as naturalist on the "Beagle" expedition, 1831-36, and made many important contributions to zoology and geology. Announced his theory of natural selection with A. R. Wallace, who had arrived at the same idea independently, in 1858. Published "Origin of Species" in 1859. This revolutionized the whole study of zoology, from the standpoint of evolution. Darwin extended his general theory to man, and continued his studies tending to the demonstration and confirmation of his views.

 Born at Elston, England, 1731; died at Derby, 1802. English physician and naturalist, grandfather of Charles R. In his writings there is much that his grandson afterward confirmed. Lamarck and others who helped develop the theory of evolution owe much to Erasmus Darwin. He wrote in prose and in

didactic verse. His "Zoonomia" was so revolutionary in its ideas, that it is said that Paley wrote his "Natural Theology" to counteract its influence.

Davy, Sir Humphry, iv, 48. Born at Penzance, 1778; died at Geneva, 1829. English physicist. Was apprenticed to a surgeon, 1795, and began to study a wide range of subjects. At the age of nineteen he settled upon chemistry. Dr. Beddoes took him as his assistant at Bristol, and he soon discovered nitrous oxide (laughing gas). Was now appointed lecturer at the Royal Institution, London, and attracted brilliant audiences. 1802, made professor of chemistry there. Made extensive researches in agricultural chemistry. Most famous of all were his his electrolytic experiments, which established Lavoisier's theories of the composition of bases. Davy decomposed potash and similar substances, and demonstrated the nature of chlorine and hydrochloric acid. In 1815 he investigated the nature of fire-damp, and invented the safety lamp. 1820, was elected President of the Royal Society. Later devised a method of preventing corrosion of copper bottoms of seagoing vessels. He died a member of nearly all the scientific institutions in the world.

Dawes, Rev. W. R., iii, 44. Born at London, 1799; died at Haddenham, 1868. English astronomer, practised medicine; also officiated for a time as minister. Had charge of several observatores in England. Discovered one of the rings of Saturn and many double stars.

De Bary, Heinrich Anton, iv, 125. Born at Frankfort-on-Main, 1831; died at Strasburg,

1888. German botanist. Studied at Heidelberg, Marburg, and Berlin. Professor at Freiburg, Halle, and Strasburg. He made a special study of fungi and was editor of the "Botanische Zeitung" from 1866 until his death.

De Forest, Lee, viii, 65. Born at Council Bluffs, Iowa, August 26, 1873. One of the pioneers of the development of wireless telegraphy and telephony in America. His system of wireless telegraphy was used extensively in the Russian-Japanese War.

Delambre, Jean Baptiste Joseph, iii, 16. Born at Amiens, 1749; died at Paris, 1822. French astronomer. Studied under Delisle and Lalande. Worked out tables of motion by Uranus after its discovery by Herschel (1781). He and Méchain superintended the measurement of the arc of the meridian (1792-99), for the base of the metric system. 1807, was made Professor of Astronomy in the Collège de France. Left numerous writings on astronomical subjects.

Delitzsch, Frederick, i, 96. Born at Erlangen, 1850; German assyriologist. Professor at Leipsic (1877), Breslau (1893), and Berlin (1899). Has written much on Assyriology and his works have attained a high degree of popularity.

Democedes, i, 172. Born at Crotona, Italy, middle Sixth Century B.C. Greek physician. Went to Greece, where he was taken prisoner by the Persians and carried to court, when he became physician to Darius I. Afterward he returned to Greece and to Crotona.

Democritus, i, 161. Born at Abdera, Thrace, cir. 470-460 B.C. Lived to a great age. Greek philosopher. Traveled extensively and was the

learned thinker of his age. Originated the atomic system, which assumed matter to be composed of indivisible atoms whose motion is derived entirely from themselves. From the combination made by the motion the whole of Nature is created. There is law in Nature, but no design. Upon his philosophy epicureanism was founded.

Descartes, René, ii, 193. Born at La Haye, 1596; died at Stockholm, 1650. French philosopher, the "father of modern philosophy." Educated by the Jesuits, he became dissatisfied with scholasticism, and resolved to free his mind from all he had learned in order to get at truth. Became a soldier and finally settled in Holland, where he wrote his books, taught, and became involved in many disputes with theologians. The principles of his systems were published in his "Discourse de la Méthode," 1637, in which he finds absolute truth only in those thoughts and ideas which are as distinct and clear as is his self-consciousness. With this system he revolutionized all methods of thought and logic. He also wrote a geometry which puts him among the leading mathematicians of his age. In 1649 he was called to Stockholm by Queen Christina and shortly after died there.

Desmoulins, Louis Antoine, iv, 249. Born at Rouen, 1794; died at Rouen, 1828. French naturalist and anatomist. Studied and practiced in Paris, where he made a special study of anatomy and the physiology of the nerve centers. He was a severe critic of Cuvier.

Dewar, Sir James, v, 39. Born at Kincardine-on-Forth, Scotland, 1842. Scottish chemist.

Educated Edinburgh, where for some years he was assistant to Lord Playfair, Professor of Chemistry. Afterward professor at Cambridge, and at Royal Institution. Made special studies of physiological action of light and liquefaction of gases.

Diodorus Siculus, i, 77. Born at Agyrium, Sicily, latter half First Century B.C. Greek historian. Set himself the task of writing a great history of the world, in preparing for which he traveled extensively in Europe and Asia, settling finally in Rome, where he lived many years. The preparation and writing of the work took not less than thirty years. It covers about 1,100 years down to the Conquest of Gaul by Cæsar.

Diogenes Laërtius, i, 121. Born at Laërte, Cilicia, about beginning Third Century A.D. Greek writer, whose principal work, "Lives of the Philosophers," in ten books, has preserved to us much knowledge of the history of Greek philosophy, although it is largely biographical, and gives little attention to the evolution of philosophic thought.

Dohrn, Dr. Anton, v, 121. Born at Stettin, 1840; died in 1908. German zoologist. Studied under Haeckel at Jena. Made special study of marine animals. 1870, founded the zoological station at Naples, the first and still the most important in existence.

Dove, Heinrich W., iii, 199. Born at Liegnitz, 1803; died at Berlin, 1879. German physicist and meteorologist. Educated Breslau and Berlin. Became professor University of Berlin, 1829. Director of the Royal Observatory. Made spe-

cial researches in climatology, meteorology, electricity, and polarized light.

Draper, Daniel, iii, 67. Born at New York, 1841. American meteorologist. Assisted his brother Henry in equipping his observatories, 1869. Made director New York Meteorological Observatory, and designed many self-recording instruments.

Draper, Dr. Henry, iii, 67. Born in Virginia, 1837; died in New York, 1882. American physician and scientist. Educated New York, Professor of Medicine, and afterward of Chemistry in New York University. Also interested in astronomy, built large telescope at Hastings-on-Hudson, and took up celestial photography with valuable results.

Draper, Dr. John W., iv, 70. Born near Liverpool, England, 1811; died at Hastings-on-Hudson, 1882. American chemist, physiologist, and writer. Educated London University. Came to America 1831. Studied University of Pennsylvania. Professor in Hampden Sidney Coll, Va., 1836. 1839, came to New York and helped found Medical School, New York University, where he was Professor of Chemistry, afterward (1850), of Physiology. Made valuable contributions to physical chemistry, especially in chemical action of light, and spectrum analysis, and he greatly improved the daguerreotype process.

Dubois-Reymond, Emil, iv, 262. Born at Berlin, 1818; died at Berlin, 1896. German physiologist. Educated at Berlin for the ministry; finally turned to chemistry and physics; later to medicine. 1858, became Professor of Physiology,

University of Berlin; 1867, perpetual secretary Berlin Academy of Sciences. He made a special study of animal electricity, and laid the foundation for all our knowledge of this subject. Invented the method for reading table messages by light deflected from a mirror attached to the needle of a galvanometer.

Dufay, Charles François de Cisternay, ii, 267. Born at Paris, 1698; died at Paris, 1739. French chemist. Destined for the army, he paid more attention to science, and soon abandoned military service to devote himself to chemistry. 1733, was made member of the Academy of Sciences, and pursued anatomy, botany, astronomy, mathematics, and mechanics as well as chemistry. Noted for his researches in the phenomena of phosphorescence and the properties of caustic soda. Made many surprising discoveries in electricity. Made many experiments in the double refraction of crystals. Through his efforts the Jardin des Plantes was greatly improved and developed.

Dujardin, Felix, iv, 124. Born at Tours, 1801; died at Rennes, 1860. French zoologist. Studied Tours and Paris. Became Professor of Zoology in the Faculté de Rennes. Made a special study of worms and insects.

Dumas, Jean Baptiste, iv, 128. Born at Alais, 1800; died at Cannes, 1884. French chemist. Was apprenticed to an apothecary in Geneva. Went to Paris and studied chemistry. Professor of Chemistry in the Athenæum, later at the Sorbonne. Made a specialty of organic chemistry; and made many valuable researches for the determination of atomic weights. Also occupied

several political positions. Was Minister of Agriculture and Commerce, 1840-1851.

Edison, Thomas A., vi, 228; vii, 182. Born at Milan, Ohio, Feb. 11, 1847. Inventor of the phonograph, the incandescent lamp and light system, a system of wireless telegraphy, and more than seven hundred other inventions, or improvements on mechanical devices.

Empedocles, i, 114. Born at Agrigentum, Sicily, cir. 490 B.C.; died cir. 430 B.C. Greek philosopher and physician. In his philosophical teachings he assumed four elements, earth, air, fire, and water, which existed together immovable in the perfect primitive world by means of an uniting cause "Friendship," until the external separating cause "Strife" entered into the world and acting on the elements gave rise to all individual and contrary phenomena.

Erasistratus, i, 194. Born at Julis, Ceos, cir. 330 B.C. Greek physician. Became body physician at Court of King Selectus Nicator of Syria. Went to live in Pamos and gave himself up to study of anatomy. He was the first to perceive the difference between the sensory and motor nerves, and traced both to the brain. He seemed to have some idea of the circulation of the blood, and of the functions of the veins and arteries.

Eratosthenes, i, 225. Born at Cyrene, cir. 275 B.C.; died at Alexandria, 195 B.C. Greek astronomer and geometer, pupil of Lysanias and Callimachus. Went to Athens. 240, succeeded Callimachus as head of the Alexandrian Library. Became blind and voluntarily starved himself to death. Attempted to measure the obliquity

of ecliptic and came within 23° of being correct. Computed the circumference of the earth to be 250,000 stadia. His geography in three books is the first scientific treatise on the subject ever attempted.

Ericsson, John, vi, 134. Born at Wermland, Sweden; died at New York, March 8, 1889. Famous Swedish-American engineer and inventor. He is best known as the inventor of the caloric engine (1833) and the turreted iron-clad Monitor (1862). He applied the screw to steamships, invented the torpedo-boat destroyer, and a type of solar engine.

Erman, Professor Adolf, i, 28. Born at Berlin, 1854. German Egyptologist. Educated Berlin and Leipsic. 1885, director of Egyptian Department, Royal Museum, Berlin. 1892, Professor of Egyptology, University of Berlin. He has put the study of the ancient Egyptian languages upon a scientific basis through a thorough study of its grammar.

Euclid, i, 193. Lived at Alexandria in Third and Fourth Centuries B.C. Greek geometer, the most famous of antiquity. He worked out a large number of the problems of elementary geometry.

Euler, Leonhard, iii, 17. Born at Basel, 1707; died at St. Petersburg, 1783. Swiss mathematician. Educated at Basel, receiving master's degree at age of sixteen. Studied mathematics, theology, Oriental languages, and medicine. 1727, went to St. Petersburg on invitation of Catherine I. Became Professor Higher Mathematics, 1733. 1740, called by Frederick the Great to Berlin to take Chair of Mathematics

in Academy of Science. 1766, recalled to St. Petersburg and died there. Contributed voluminously to the science of mathematics.

Eustachio, Bartolommeo, ii, 165. Born at San Severino, early in Sixteenth Century; died in 1574. Italian anatomist. 1562, became Professor of Medicine in the Collegio della Sapienza, Rome. Discoverer of the eustachian tube in the ear, and the rudimentary valve of the heart. He first described the thoracic duct, and perhaps also first noticed the stapes. He materially increased knowledge in regard to the teeth and the kidneys. He was one of the founders of modern anatomy.

Evans, Oliver, vi, 113. Born at Newport, Del., 1755; died at New York, 1819. American mechanician and inventor. Made valuable improvements in mill machinery. Said to have designed (1795) first high-pressure engine.

Falconer, Hugh, iii, 99. Born at Forres, Scotland, 1808; died at London, 1865. Scottish botanist and paleontologist. Educated at Aberdeen and studied medicine at Edinburgh. Spent most of his life in India, where he went in 1829. On his recommendation tea culture was introduced into India. Discovered the asafœtida plant. Found many important vertebrate fossils in Northern India. Was superintendent of the botanical garden at Saharanpur, and in 1847 was made superintendent of Calcutta Botanical Garden, and professor of botany in the medical college there.

Fallopius, Gabriello, ii, 166. Born at Moderna, Italy, 1523; died at Padua, Oct. 9, 1562. Celebrated Italian anatomist. Professor of anatomy

at Ferrara, Pisa and Padua. Made several important discoveries in the anatomy of the ear, the fallopian tube being named for him. In the controversy over the question as to whether there are valves in the veins, Fallopius declared that he was unable to find such valves. The fact of their existence was established by his contemporaries.

Faraday, Michael, iii, 241. Born near London, 1791; died at Hampton Court, 1867. English chemist and physicist. Apprenticed to a bookbinder, he gave all his spare time to science, especially experiments in electricity. Davy became interested in him and took him as assistant. He became one of the most brilliant experimentalists science has ever known. Liquified certain gases by pressure. Discovered the revolution of a magnetic needle due to an electric current. Discovered action of currents on each other and laid the foundation of magneto electricity. Valuable researches in electrolysis. Discovered benzol, the basis of aniline dyes.

Fechner, Gustav, iv, 263. Born at Gross-Sährchen, 1801; died at Leipsic, 1887. German physicist and philosopher. He founded modern psychology, and psycho-physics. Educated, Leipsic for a physician, but turned to physics. Researches in electricity and physiological optics. After 1845 devoted himself to philosophy. Advocated mentality of a low order in the plant world. Worked out a comprehensive system of metaphysics. In his most famous work, "Psychophysik," he developed the psychophysical measurement methods which are still in use to-day.

pellier. Assistant and successor to Cuvier, as Professor of Natural History in the Jardin du Roi. 1835, became professor in the College de France. A voluminous writer on comparative anatomy and physiology, natural history, etc. Wrote a famous work on the formation of the bones. Made a peer by Louis Philippe, 1846.

Forbes, James David, iii, 275. Born at Edinburgh, 1809; died at Clifton, England, 1868. Scottish physicist and geologist. Educated, Edinburgh, for the law, but his natural bent led him to physics. 1833, became Professor of Physics, Edinburgh University. Made special study of thermal radiations which resulted in the discovery of the polarization of heat. Made important contributions to our knowledge of the origin and movement of glaciers.

Foster, Sir Michael, v, 17. Born at Huntington, Eng., 1836. English physiologist. Educated University College, London. Taught there and at Cambridge. Became Professor of Physiology, Cambridge University, 1883. 1900, member of Parliament for London University.

Foucault, Jean Bernard. Born at Paris, 1819; died at Paris, 1868. French physicist. Educated for the medical profession. 1854, appointed Physicist, Paris Observatory. First direct measurements of velocity of light were due to him and Fizeau. Showed that velocity of light in air was greater than in water. Invented polarizing prism, and an apparatus for regulating electric light. Made many researches in electricity. The Foucault currents were named after him.

Fourneyron, Benôit, vi, 72. Born at St.

Etienne, France, Oct. 31, 1802; died at Paris, July, 1867. French engineer who improved the construction of turbine water-wheels.

Franklin, Benjamin, ii, 286. Born at Boston, 1706; died at Philadelphia, 1790. American scientist and statesman. Apprenticed to a printer he soon went to Philadelphia and began a life of great public activity, rendering great service to his country in many ways. He held political offices, spent much time in Europe on behalf of the colonies, and later as an emissary of the new American nation to obtain help from France. In 1731 he started the Philidelphia Library. In 1744, founded the American Philosophic Society. Invented the Franklin stove, made many civic improvements, and made valuable investigations in electricity, demonstrating the electrical nature of lightning (1752).

Frauenhofer, Joseph von, iii, 60.. Born at Straubing, 1787; died at Munich, 1826. German physicist. Began life as a working optician and became head of a firm of opticians. Invented means of obtaining large piece of optical glass free from imperfections for lenses and prisms. Many inventions to perfect making of lenses, prisms, etc. Discovered the dark lines in the spectrum called by his name. Measured the wave lengths of sodium light by means of diffraction grating.

Fresnel, Augustin Jean, iii, 226. Born at Broglie, 1788; died near Paris, 1827. French physicist. Educated Caen and Paris. Became Government engineer. Independently of Young he demonstrated the falsity of the Newtonian theory of light, and advocated the undulatory the-

refracting telescope, with which he discovered the satellites of Jupiter (1610), phases of Venus, sun-spots, etc. In his work on the sun-spots he advocated the Copernican theory, and was denounced as a heretic. Was tried and compelled to recant his views. Imprisoned, but soon released and retired to Florence.

Gall, Franz Joseph, iv, 248. Born at Tiefenbronn, 1758; died at Montrouge, 1828. German physician and phrenologist. Studied Strasburg and Vienna, practiced in latter city. 1796, began to lecture on structure and function of brain, and for his views the Austrian Government compelled him to leave Vienna, 1802. Settled finally in Paris, practiced and lectured. Here he continued to lay the foundations of phrenology, in spite of charges of materialism and fatalism constantly brought against his system.

Galton, Francis. Born at Birmingham, 1822. English anthropologist and meteorologist. Educated Birmingham, London, and Cambridge. 1850, started to explore in Africa and discovered the Orampo race. Promulgated the theory of anti-cyclones (1863), which is the foundation of weather forecasts. Of late years his studies have been mostly in anthropology and biology. His views on heredity have been widely discussed. He was the first to apply statistics to anthropology and invented the means of taking composite photographs. Has devised various measuring apparatuses for purposes of psychology.

Galvani, Luigi, iii, 229. Born at Bologna, 1737; died at Bologna, 1798. Italian physician and anatomist. Educated for the priesthood but

turned to medicine. Was Professor of Anatomy at Bologna. By an accident he discovered the existence of the galvanic current, which led to the invention of the voltaic cell and all that has developed from it.

Gauss, Karl Friedrich. Born at Brunswick, 1777; died at Göttingen, 1855. German mathematician, one of the most brilliant of modern times. Born in poverty, but was educated at Göttingen. Invented a method of calculating positions of heavenly bodies in order to rediscover the lost planet Ceres. Devoted latter part of life to geodesy and the mathematical theory of electricity. Developed the theory of least squares.

Gay-Lussac, Joseph Louis, iv, 41. Born at Saint-Léonard le Noblat, 1778; died at Paris, 1850. French chemist and physicist. Studied at Paris. Became assistant to Berthollet at the Government chemical works. Made balloon ascent to ascertain whether magnetic force existed above the earth. With Humboldt he announced the exact composition of water (1804), which led to the discovery by Gay-Lussac in 1808 of the important law of volumes. 1809, became Professor of Chemistry at École Polytéchnique. Discovered a better way than electrolysis for producing potassium.

Geber, ii, 20. Died about 1776. An Arabian chemist. He discovered sulphuric, nitric, and nitromuriatic acids, thus greatly increasing the possibilities of chemical experiment. He is credited with writing about five hundred works. Of these "Testamentum," "De Inventions Vintatis," "Liber Fornacum," "Summa Perfectionis," "De

Investigatione Perfectionis," and "Liber Investigationis," have appeared in print.

Gilbert, William, ii, 111. Born at Colchester, England, 1540; died Nov. 30, 1603. English physician and natural philosopher. Physician in ordinary to Queen Elizabeth and James I. President of the College of Physicians in 1600. With the doubtful exception of Bacon, Gilbert was the most distinguished man of science during the reign of Queen Elizabeth. His studies of electricity and magnetism led Priestly to call him "the father of modern electricity." He was the first to discover that the earth is a magnet, and explained the dipping of the needle by the magnetic poles. He also gave the name of "pole" to the extremities of the magnetic needle, and was first to make use of the terms "electric force" and "electric attractions." He was first to distinguish between magnetism and electricity, and made the first electrical instrument ever constructed. He made also the first electrical indicating device. The method of magnetising iron first introduced by him is in common use to-day.

Gill, Sir David, iii, 67. Born at Aberdeen, Scotland, June 12, 1843. Scottish astronomer and Astronomer Royal at the Cape of Good Hope from 1879. He made five photographs of a comet, and the flecks of starlight on his plates first suggested the possibilities of this method in charting the heavens. His observations of the transit of Venus in 1882 were invaluable in the determination of the distance of the sun from the earth.

Gladstone, Professor J. H., iv, 68. Born at

London, 1827; died October, 1902. English scientist. Professor of Chemistry at the Royal Institution, 1874-77. Published "Life of Michael Faraday," and "Chemistry of Secondary Batteries."

Goethe, Johann Wolfgang von, iv, 140. Born at Frankfort-on-the-Main, Aug. 28, 1749; died at Weimar, March 22, 1832. German poet, dramatist, and scientist. In 1790 published the "Metamorphoses of Plants," in which he advanced the novel doctrine that all parts of the flower are modified or metamorphosed leaves. A little later he advanced the doctrine that the vertebrate skull is essentially a modified and developed vertebra. This doctrine of metamorphosis of parts soon came to be regarded as of fundamental importance.

Goodyear, Charles, ix, 113. Born at New Haven, Conn., Dec. 29, 1800; died at New York, July 1, 1860. American manufacturer. He discovered the process of treating india-rubber known as "vulcanization," a process upon which the usefulness of rubber is largely dependent. He also invented a machine for the sewing of soles, known as a "turn-sole machine," which was of great commercial importance.

Gordon, Andrew, ii, 279. Born at Coforach, Forfarshire, June 15, 1712; died Aug. 22, 1751. A Scotch Benedictine monk and physicist, noted for his experiments in frictional electricity. He was first to invent an electric bell which would ring automatically, and a "motor," in the form of a wheel which was revolved by the action of electricity. He demonstrated the force of the electric current by killing birds and small ani-

mals at a distance of two hundred ells, the current being conveyed by small wires.

Gray, Asa, iv, 175. Born at Paris, New York, Nov. 18, 1810; died at Cambridge, Mass., Jan. 30, 1888. American botanist. Professor of Natural History at Harvard, 1842-88. Championed Darwin's theory of evolution, and wrote "Darwiniana" in 1876. Some of his best-known works are, "Elements of Botany," "Flora of North America," "How Plants Grow," "Field, Forest and Garden Botany," and "Manual of Botany of the United States."

Gray, Prof. Elisha, vii, 85; viii, 26. Born at Barnesville, Ohio, Aug. 3, 1835; died at Newtonville, Mass., Jan. 20, 1901. American inventor. Remembered particularly for his inventions relating to telegraphy and the telephone. He filed specifications of a telephone in the United States Patent Office only a few hours later than Dr. Graham Bell, whose invention opened the era of telephonic communication.

Gray, Stephen, ii, 262. Died February 25, 1736. A pensioner of the Charter House in London. In his experiments with electricity he discovered two of the most important properties of electricity—that it can be conducted and insulated.

Guericke, Otto von, ii, 213. Born at Magdeburg, Prussia, Nov. 20, 1602; died at Hamburg, May 11, 1686. German natural philosopher. He invented the first electrical machine, and discovered electrical attraction and repulsion. He invented the air pump and the air balance, and demonstrated the pressure of the atmosphere

with the "Magdeburg hemispheres," see Vol. ii, 211.

Guy of Chaulic, ii, 38. Born about 1300. Famous French surgeon. Introduced the treatment for broken limbs by suspension in a cradle, and the method of making "traction" to prevent deformity by shortening of the member—a method still in use. He was one of the first physicians to advocate the use of glasses in certain eye disorders.

Haeckel, Ernst Heinrich, v, 144. Born at Potsdam, Prussia, Feb. 16, 1834. Distinguished German naturalist. One of the leading advocates of the biological theory of evolution. For a time he practiced medicine in Berlin, but in 1861 he left the field of medicine to become a privat-docent in Jena. In 1865 he was appointed to a chair of zoology which was specially established for him. He has written many monographs of systematic and descriptive nature, these works alone "constituting a good life's work." In addition he has written several other works, some of them of a popular nature. In 1866 he published his "General Morphology," and about two years later he rewrote the same work in a more popular style, published as the "Natural History of Creation." In his book "Die Welt-räthsel," published in English as "The Riddle of the Universe," he applies the doctrine of evolution to the problems of philosophy and religion carried to its logical conclusion.

Hahnemann, Christian Samuel Friedrich von, iv, 189. Born at Meissen, Saxony, April 10, 1755; died at Paris, July 2, 1843. German physician, founder of homeopathy. His new system

of medicine was expounded about 1796, and later elaborated in his work "Organon der Rationellen Heilkunde."

Hales, Stephen, ii, 298. Born at Bekesbourne, Kent, Sept. 7, 1677; died at Teldington, near London, Jan. 4, 1761. English clergyman, inventor, and physiologist. His most important invention was a "ventilator" for introducing fresh air into jails, mines, ships' holds, etc. Only four deaths in four years occurred in the Savoy Prison after this ventilator was introduced there, whereas the mortality previous to that time had been from 50 to 100 per annum. Hales' work, "Vegetable Statics" (1727), on the subject of vegetable physiology was the first important publication on the subject.

Hall, Marshall, M.D., F.R.S.L., iv, 251. Born at Basford, Notts, Feb. 18, 1790; died at Brighton, England, Aug. 11, 1857. English physician, the discoverer of the phenomena known as reflex action. This discovery marked an epoch in physiology. The most popular of Hall's discoveries was his "ready method" for resuscitating in drowning, by which innumerable lives have been saved.

Haller, Albrecht von, iv, 73. Born at Bern, Switzerland, Oct. 16, 1708; died at Bern, Dec. 17, 1777. Anatomist, physiologist, botanist, and poet. A sickly, but precocious child, he read and expounded the Bible at the age of four; and before ten years of age had "sketched a Chaldee grammar, prepared a Greek and a Hebrew vocabulary, and compiled a collection of two thousand biographies of famous men and women." His greatest contribution to medicine was his

Harvey, William, ii, 169. Born at Folkestone, England, April, 1578; died at Hempstead, Essex, June 3, 1657. An English physician, famous as the discoverer of the circulation of the blood. His experiments to demonstrate his theory were made upon serpents, and his demonstrations were such that his conclusions were accepted almost immediately by scientists all over the civilized world.

Hauksbee, Francis, ii, 259. English physicist, one of the early experimenters with electricity. Through experiments with a whirling globe from which the air had been exhausted, and with a barometer and rubbed glass rods he produced a glow which he found to be electrical. He also discovered the important property of electricity known as "induction" by revolving two cylinders placed about an inch apart.

Helmholtz, Hermann Ludwig Ferdinand von, iii, 280. Born at Potsdam, Aug. 31, 1821; died at Berlin, Sept. 8, 1894. German physiologist and physicist. At the age of twenty-two he was military physician at Potsdam. Later was Professor of Anatomy and Physiology at Bonn, Professor of Physiology at Heidelberg, and Professor of Physics at Berlin. In 1851 he invented the ophthalmoscope—an instrument invaluable to oculists for examining the internal structures of the eye. He formulated an electro-magnetic theory of light, which was shown to be correct by the experiments and discoveries of his pupil, Heinrich Hertz.

Henderson, Thomas, iii, 61. Astronomer Royal of Scotland. He was one of the first astronomers to detect and measure the parallax of

a star, in point of time his observations preceding Bessel's, although Bessel's were much more numerous. These observations solved the problem of star distance.

Henry, Joseph, iii, 239; vi, 175. Born at Albany, N. Y., Dec. 17, 1797; died at Washington, D.C., May 13, 1878. An American physicist, and secretary of the Smithsonian Institution. Noted for his experiments in electro-magnetism. He constructed electro-magnets of greater power than any hitherto known, and was the first to adopt insulated or silk-covered wire for the magnetic coil. He invented a magnetic bell for signaling, which is considered the first example of a true magnetic telegraph. Foreign estimates place him in the foremost rank of American physicists of the Nineteenth Century.

Heraclides, i, 196. A Greek physician, who decried the study of anatomy, depending entirely upon the use of drugs for curing diseases. He is said to be the first physician to use opium in painful affections.

Hero, i, 242. Alexandrian mathematician of the Third Century, B.C. He wrote several works, only one of which, "Pneumatics," has been preserved. In his studies of gas, liquids and solids, he shows a fairly clear conception of the "atomic" nature of matter. He describes also the mechanism of various mechanical toys and devices, among them a ball rotated by the action of steam.

Herodotus, i, 103. Born at Halicarnassus, Asia Minor, about 484 B.C.; died at Thurii, Italy, about 424 B.C. Celebrated Greek historian, called "the Father of History." In his

writings he tells of an eclipse which occurred in 585 B.C. (modern astronomers reckon the exact date to be May 25th), which had been foretold by Thales. This is the first recorded instance of a predicted eclipse.

Herophilus, i, 194. Lived about 300 B.C. Greek anatomist and physician. With Erasistratus, the earliest scientific investigator of the mechanism of the human body. Discovered that the nerve trunks have their origin in the brain and spinal cord, and are of two different kinds, motor and sensory. Also made fairly accurate study of the anatomy of the eye.

Herschel, Sir John, iii, 58; iv, 111. Born near Windsor, March 7, 1792; died at Collingwood, Kent, May 11, 1871. English astronomer; son of Sir William Herschel. Made important observations of double stars. In 2,299 telescopic fields he counted 68,948 stars. In his studies of the milky way he estimated that the stars visible in a reflecting telescope of 18 inches aperture amounted to over five million.

Herschel, Sir William, iii, 20. Born at Hanover, Prussia, Nov. 15, 1738; died at Slough, England, Aug. 25, 1822. Celebrated English astronomer of German birth. Deserted from German army and went to England in 1757. Gained considerable success as violinist, organist, and teacher of music. Was self-instructed in mathematics and astronomy, and constructed his own telescopes. He discovered the planet Uranus in 1781, and the following year was made Court astronomer. With his forty-foot reflecting telescope he determined definitely that the stars are suns, not merely "points of light" as had

been believed by many, even in the Eighteenth Century, and made pioneer observations in nearly every branch of astronomy.

Hertz, Heinrich Rudolf, iii, 247. Born at Hamburg, Germany, Feb. 22, 1857; died at Bonn, Jan. 1, 1894. German physicist. In 1883 he began studies in Maxwell's electro-magnetic theory, and finally established the fact that "ordinary light consists of electrical vibrations in an all-pervading ether, which possesses the properties of an insulator and of a magnetic medium." The results of his observations have been turned to practical account in the wireless telegraph and telephone systems of the present time.

Hevelius, Johannes, iii, 3. Born at Dantzic, Prussia, Jan. 28, 1611; died at Dantzic, Jan. 28, 1687. A Polish astronomer. His fame as an astronomer rests largely on his accurate description of the face and the spots of the moon. He was a friend and coworker of Edmund Halley, the English astronomer.

Hewitt, Peter Cooper, vi, 236. Born at New York. American electrician. Inventor of the mercury-vapor electric light, in which mercury vapor takes the place of the carbon or metal filament of the incandescent lamp.

Hildanes, Fabricius, ii, 183. Born in 1560; died in 1639. A German physician and surgeon. He invented many useful surgical instruments, several of them for locating and removing bullets. Contrary to the teachings of his time he was an ardent advocate of the study of anatomy. He was first to use a magnet for removing particles of metal from the eye.

Hinrichs, Professor Gustav, iv, 67. An Amer-

ican chemist. One of the first to conceive the so-called "law of octaves," which later was explicated fully by Mendelèeff under the title of "the periodic law."

Hipparchus, i, 233. Born at Nicæa, in Bithynia, 160 B.C. A Greek astronomer called "the lover of truth," one of the founders of scientific astronomy. He discovered the precession of the equinoxes, some of the inequalities of the moon's motion, and the eccentricity of the solar orbit.

Hippocrates, i, 170. Born at Island of Cos, about 460 B.C.; died at Larissa, Thessaly, about 377 B.C. A Greek physician, termed the "Father of Medicine." His most revolutionary step was divorcing the supernatural from the natural, and establishing the fact that disease is due to natural causes. This led to closer and systematic observation of cases, and written observations—"clinical histories" as they are called. Some of the surgical procedures described by him are followed, with slight modifications, by modern surgeons.

Hoffman, Friedrich, iv, 184. Born at Halle, Prussia, Feb. 19, 1660; died at Halle, Nov. 12, 1742. A celebrated German physician. He arranged the doctrines of Boerhaave into a "system" which considered force inherent in matter, expressed as mechanical movements, and determined by mass, number, and weight. He introduced several new remedies, one of them "Hoffman's anodyne" (spirits of ether), which is still in use.

Holland, John P., vii, 105. Born in 1841. American inventor. Began building submarine boats in 1875, and in 1900 had so perfected them

were afterward universally adopted. He held that clouds are composed of vapor that has previously risen from the earth.

Howe, Elias, ix, 93. Born at Spencer, Mass., July 9, 1819; died at Brooklyn, N. Y., Oct. 3, 1867. American inventor. He invented a sewing-machine in 1845, which is considered the direct ancestor of all modern sewing-machines. It used an eye-pointed needle, and a shuttle, such as sewing-machines use at present.

Huggins, Sir William. Born at London, Feb. 17, 1824; died in May, 1910. English astronomer. He was a pioneer in utilizing spectroscopy and photography together. In 1864 he discovered that the planetary nebula in Draco consists of luminous gas. In 1868, through use of the spectroscope, he proved the existence of carbon in comets. His name is closely associated with most recent advances in spectrum analysis.

Humboldt, Alexander von, iii, 192. Born at Berlin, Sept. 14, 1769; died at Berlin, May 6, 1859. Celebrated German scientist and author. In a paper on isothermal lines and the distribution of heat on the earth he laid the foundation for a science of comparative climatology. He made extensive journeys in South America, Mexico, Siberia and the Caspian Sea region for scientific observation. His "Kosmos" published in 1845-58 is perhaps the greatest of his books.

Hunter, John, iv, 78. Born at Long Calderwood, Scotland, Feb. 13, 1728; died at London, Oct. 16, 1793. British surgeon, anatomist and physiologist. First to discover the system of vessels known as lymphatics, although the function of these vessels was suggested by his

brother, William Hunter. His studies of tendons laid the foundation for the operation for the cure of club feet. His experiments to determine the blood-supply for the growing antler of a deer led to the discovery of the "collateral circulation of the blood"—one of the most important discoveries in surgery. This led directly to his invention of the "Hunterian" operation for aneurism, an operation still in use, and which has made the name of Hunter immortal in the annals of surgery.

Hunter, William, iv, 76. Born at Long Calderwood, Scotland, May 23, 1718; died at London, March 30, 1783. British physician, anatomist and physiologist. The first great teacher of anatomy in England. He discovered the function of the lymphatics, and his writings on the structure of the synovial membranes, in 1743, anticipated Bichat's writing on the same theme by sixty years. He established a museum which is now the property of the University of Glasgow.

Hutton, James, iii, 178. Born at Edinburgh, June 3, 1726; died March 26, 1797. Scottish geologist. One of the founders of geological science. In his "Theory of the Earth," he expounded the doctrine that the present rocks of the earth's surface have been formed out of the waste of older rocks; that these materials have been laid down under the sea and consolidated by great pressure; that the expansive power of subterranean heat afterward upheaved them, and that masses of molten rock were injected into the gaps of the disrupted strata.

Huxley, Thomas Henry, iii, 112; iv, 174. Born

at Ealing, England, May 4, 1825; died at Eastbourne, June 29, 1895. English biologist. Foremost English champion of Darwin's theory of evolution, his active interest in the subject being largely responsible for the early acceptance of Darwin's conception.

Huygens, Christian, ii, 218. Born at The Hague, April 14, 1629; died there June 8, 1695. A celebrated mathematician, physicist, and astronomer. He was the inventor of the pendulum clock. With his brothers he constructed a telescope with which he discovered a hitherto unknown satellite of Saturn. Later he adapted the micrometer to the telescope, this being a mechanical device upon which the nice determination of minutes depends. One of his many interesting papers sent to the Royal Society was his "Rules Concerning the Motion of Bodies after Mutual Impulse," in which the laws of motion are stated in remarkably clear and concise terms.

Jackson, Dr. Charles Thomas, iv, 215. Born at Plymouth, Mass., June 21, 1805; died at Somerville, Mass., Aug. 29, 1880. American physician and geologist. One of the claimants to the discovery of etherization. Also claimant to the invention of a telegraph similar to Morse's.

Jacquard, Joseph Marie, ix, 49. Born at Lyons, France, July 7, 1752; died near Lyons, Aug. 7, 1834. French mechanic and inventor. He invented the Jacquard loom about 1801. Modifications of this loom are still used extensively for weaving designs and patterns.

Jansen (or Zanss) **Zacharias,** ii, 77. A Dutch

optician. About 1590 placed a concave and a convex lens respectively at the end of a tube, and used this device for magnifying small objects. This is the first recorded instance of the use of a compound microscope.

the alphabet. According to the legend, he was the son of a Phœnician king.

Kant, Immanuel, iii, 26. Born at Königsberg, Prussia, April 22, 1724; died there Feb. 12, 1804. Celebrated German philosopher. He conceived the nebular hypothesis which attempted to explain world formation along rational lines. The puzzling questions left unanswered by Kant were answered by Laplace's nebular hypothesis (see Vol. iii, 31).

Kay, John, ix, 22. Born near Bury, Lancashire, July 16, 1704; died in France about 1764-5. English mechanic and inventor. He invented the "flying shuttle," a power loom, and several other aids to weaving. On account of these inventions mobs of workmen wrecked his house, stole his machines, and drove him from the country.

Kay, Robert, ix, 43. Son of John Kay. In 1760 he invented the "drop-box," a device which enabled the weaver to insert several colors as strips across the length of his loom with great facility.

Kelvin, Lord (William Thomson), iii, 165; v, 106. Born at Belfast, Ireland, June 1829; died at London, Dec. 17, 1907. Celebrated British physicist. Active in almost every field of natural philosophy. Took an active part in laying the Atlantic cable, and invented the mirror-galvanometer and siphon-recorder in connection with that work. Was first to maintain that the earth is practically solid to the center and has the rigidity of steel. Invented the short-needle compass now in universal use by mariners. Was

Kunz, Dr. George F., v, 101. Born at New York, Sept. 20, 1856. American gem expert. Special agent of the United States Geological Survey in 1883. Had charge of the department of mines, World's Columbian, and Paris Expositions. Has written extensively on gems and minerals. Author of "Gems and Precious Stones of North America," "Mineral Resources of the United States," etc. The recently discovered precious stone kunzite was named in his honor.

Lacaille, Nicolas Louis de, iii, 13. Born at Rumigny, France, March 15, 1713; died at Paris, March 21, 1762. Noted French astronomer. Measured the French arc of the meridian in 1739-41. In 1751 he went to the Cape of Good Hope and made many important observations on the stars of the southern hemisphere. While on this expedition he determined the sun's parallax by observing the parallaxes of Mars and Venus.

Laennec, René Théophile Hyacinthe, iv, 201. Born at Quimper, France, Feb. 17, 1781; died Aug. 13, 1826. French physician. He was the inventor of the stethoscope, an instrument which is of great aid in diagnosis of diseases of the heart and lungs.

Lamarck, Jean Baptiste De, iv, 151. Born at Bazentin, France, Aug. 1, 1744; died at Paris, Dec. 18, 1829. French naturalist. His work helped directly to lay the foundation for Darwin's doctrine of evolution. His views differed from Darwin's about the part played by the active exertion of the organism and by "appetency."

English clergyman and inventor. About 1589 he invented a knitting machine which would knit at a rate more than ten times faster than could be done by hand. The English hand-knitters opposed the use of this invention, and it was not until after the death of the inventor that his machine was put to practical use.

Leeuwenhoek, Anthony van, ii, 179. Born at Delft, Netherlands, Oct. 24, 1632; died at Delft, Aug. 26, 1723. Dutch microscopist and naturalist. Discovered microbes in the secretions of the mouth in 1683. He also discovered red blood-corpuscles, spermatozoa, and the capillary circulation of the blood.

Leibnitz, Gottfried Wilhelm von, ii, 197. Born at Leipsic, July 6, 1646; died at Hanover, Nov. 14, 1716. German philosopher and mathematician. Called, with reason, "a universal genius." He was the inventor of the differential and integral calculus. He conceived the theory that the entire universe is composed of individual centers, or monads, and deduced the doctrine of pre-established harmony. His influence on the scientific thought of his time was very marked.

Leidy, Joseph, iv, 207. Born at Philadelphia, Sept. 9, 1823; died April 30, 1891. American naturalist. In 1827 he discovered the cyst of "Trichina spiralis" in pork. He made important discoveries and wrote extensively on the subject of extinct vertebrate fauna.

Leonardo, Vinci, da, i, 129; ii, 47. Born at Vinci, Italy, 1452; died near Ambrosie, France, May 2, 1519. Famous Italian artist, architect, musician, and scientist. Perhaps the most uni-

versal genius that ever lived. As a scientist he anticipated Copernicus in determining the movement of the earth, and made elaborate calculations to prove that the earth moves. He invented a dynamometer for determining the traction power of machines and animals, and invented a "steam engine" which "drove a ball weighing one talent over a distance of six stadia." He is credited with the discovery of the camera obscura. He observed the deposit of fossil shells in rocks, and drew the correct conclusion that these had been deposited at the bottom of the sea, even though now resting on the tops of mountains. He drew designs for flying machines of the aeroplane type, with bird-like wings. He was so far in advance of the scientific knowledge of his time that his efforts produced few immediate results.

Lepsius, Karl Richard, i, 27. Born at Naumberg, Prussia, Dec. 23, 1810; died at Berlin, July 10, 1884. German Egyptologist and philologist. His work helped in clearing the field for our present knowledge of ancient Egypt.

Leucippus, i, 161; lived about 500 B.C. Greek philosopher. Originated (with Democritus) the atomic theory of matter.

Lewes, George Henry, i, 131. Born at London, April 18, 1817; died Nov. 30, 1878. English philosophical writer. Wrote extensively in many fields of scientific thought, throwing much light on the Greek philosophers, and, in modern times, such scientists as Comte and Goethe.

Liebig, Baron Justin von, iv, 131. Born at Darmstadt, May 12, 1803; died at Munich, April 18, 1873. German chemist. Celebrated for his

researches in organic chemistry, and the application of chemistry to food and agriculture. He demonstrated that the source of animal heat is really the consumption of the fuel taken in through the stomach and lungs.

Lilienthal, Otto, vii, 278. Born at Anklam, Germany, May 23, 1848; died Aug. 9, 1896. German engineer and pioneer in aviation. His experiments with gliding machines and his successful flights with various types of gliders gave the impetus to invention that culminated in the invention of the Wright Brothers' aeroplane. He was killed by a fall from one of his gliders.

Linnaeus, Carolus, ii, 299. Born at Rashult, Sweden, May 13, 1707; died at Upsala, Sweden, Jan. 10, 1778. Swedish naturalist and botanist. Founder of the "Linnaeus system" in botany, which has since been supplanted.

Lippershey, Johannes, ii, 78. Died 1619. One of the first to experiment with combinations of lenses to form a telescope. The instrument as constructed by him is still known as the "Dutch Telescope."

Lister, Dr. Joseph (Lord Lister), iv, 229; v, 19. Born April 5, 1827. Noted English surgeon, the father of antiseptic surgery. He began publishing the results of his researches in 1867, but it was not until about ten years later that their full significance had been demonstrated in practical surgery. The rapid advances in surgery made during the past quarter of a century are due largely to Lister's revolutionary discovery.

Lister, Joseph Jackson, iv, 113. Born at London, Jan. 11, 1786; died Oct. 24, 1869. English

physiologist for his opposition to the theory of a "vital force." His famous paper opposing this doctrine appeared in 1852.

Lubbock, Sir John, iv, 175. Born at London, March 26, 1803; died near Farnborough, Kent, June 20, 1865. Celebrated English mathematician and astronomer. He was one of the first to champion Darwin's theory of evolution. His best known work is "On the Theory of the Moon and on the Perturbations of the Planets."

Ludolff, Christian Friedrich, ii, 276. German scientist, particularly remembered for his demonstration that electric sparks are actual fire. This demonstration was made before the Academy of Science at Berlin in 1744, and consisted of touching the surface of a spoonful of sulphuric ether with a charged glass rod, causing it to burst into flame.

Lyell, Sir Charles, iii, 84. Born at Kinnorby, Forfarshire, Scotland, Nov. 14, 1797; died at London, Feb. 22, 1875. Celebrated British geologist. He is especially famous as an opponent of the old catastrophism in geology, and it was largely through his efforts that this doctrine was finally overthrown. His views were bitterly opposed and were not accepted universally for something like a quarter of a century after he had propounded them.

Magendie, Francois, iv, 203. Born at Bordeaux, France, Oct. 15, 1783; died at Paris, Oct. 7, 1855. A noted French physician, anatomist and physiologist. He was one of the experimental physiologists of the early Nineteenth Century who laid the foundation for modern scientific medicine. He is especially remem-

bered for his experiments on the physiology of the nerves.

Malpighi, Marcello, ii, 179. Born near Bologna, Italy, March 10, 1628; died at Rome, Nov. 29, 1694. An Italian anatomist and physiologist. He is remembered as the father of microscopic anatomy. As early as the year 1661 he discovered the capillary vessels connecting the veins and arteries by the aid of the microscope. A little later he observed the passage of the blood corpuscles through these minute vessels, making his observations on the lung of a turtle. His work completed the last link of the chain which Harvey had all but established in proving the course of the circulation of the blood.

Marchettis, Peter, ii, 185. (1589-1675.) An Italian physician, one of the leading surgeons of the Seventeenth Century.

Marconi, Guglielmo, viii, 14. Born at Bologna, Italy, April 25, 1874. Italian inventor. Noted for perfecting a system of wireless telegraphy. In 1899 he began sending messages across the English Channel, and this date may be considered as opening the era of wireless telegraphy.

Mariotte, Edme, ii, 210. Born at Burgundy about 1620; died at Paris, May 12, 1684. French physicist. He demonstrated that but for the resistance of the atmosphere, all bodies, whether light or heavy, dense or thin, would fall with equal rapidity. He proved this by the well-known "Guinea-and-feather" experiment—placing a coin and a feather in a tube from which the air had been exhausted, and showing that

the rate of falling in a vacuum was the same. The name "Mariotte's law" is given to the principle discovered by Boyle that the volume of a given mass of gas varies inversely as the pressure which it bears at any given temperature.

Marsh, Othniel Charles, iii, 107. Born at Lockport, New York, Oct. 29, 1831; died at New Haven, Conn., March 18, 1899. American paleontologist. He is especially remembered for his work in collecting and classifying the fossils found in the Rocky Mountain region. It was he who discovered the earliest progenitors of the horse, the fossil remains of which were found during this extensive work in the West.

Maspero, Gaston Camille Charles, i, 28. Born at Paris, June 24, 1846. French Egyptologist. His best known work is "History of the Ancient People of the Orient."

Maupertius, Pierre Louis Moreau de, iv, 149. Born at St. Malo, France, July 17, 1698; died at Basel, Switzerland, July 27, 1759. French astronomer, mathematician, and philosopher. In 1736-37 he went to Lapland and measured accurately a degree of longitude. He supported the Newtonian theory against the Cartesians, and had conceived vaguely the idea of transmutation of species.

Maury, Matthew Fontaine, iii, 196. Born at Spottsylvania County, Va., Jan. 14, 1806; died at Lexington, Va., Feb. 1, 1873. American naval officer, hydrographer and meteorologist. Advocated a theory of gravitation as the chief cause of ocean currents. He gave the first complete description of the Gulf Stream.

Maxim, Sir Hiram Stevens, vi, 228; vii, 283.

for his invention of the Mercator system of projection of maps.

Meyer, Lothar, iv, 68. He conceived the so-called "Law of Octaves" afterward fully explicated by Mendeléeff (q.v.) under the title of "The Periodic Law."

Mohl, Hugo von, iv, 125. (See von Mohl.)

Mohr, Karl Friedrich, iii, 257. Born at Coblenz, Germany, Nov. 4, 1806; died at Bonn, Sept. 27, 1879. German chemist and physicist. He was first to state the doctrine of the conservation of energy which he had independently conceived. He did not demonstrate the validity of his conception as clearly as Mayer did five years later, but his conception is apparently the first ever recorded.

Moissan, Prof. Henri, ix, 328. Born at Paris, Sept. 28, 1852; died Feb. 20, 1907. French chemist. Noted for his accomplishments with the electric furnace. In 1892 discovered a method of manufacturing acetylene at a cost that is commercially profitable. In 1893 formed diamonds from iron melted in an electric furnace and cooled suddenly.

Mondino of Bologna, ii, 37. Born in 1276; died in 1326. An Italian physician known as the "restorer of anatomy." He is known to have made careful dissections of the human body, and his writings on anatomy based on his observations were a step in advance over the generally accepted writings of Galen.

Montgolfier, Joseph Michel, vii, 230. Born at Ardèche, France, 1740; died at Balarnc, France, June 26, 1810. French mechanician and in-

ventor. With his brother invented the hot-air balloon, a public exhibition being given in 1782.

Montgolfier, Stephen, vii, 230. Born at Ardèche, France, Jan. 7, 1745; died in Servieres, Aug. 2, 1799. French mechanician and inventor (with his brother Joseph, q.v.) of the hot-air balloon.

Morgagni, Giovanni Battista, iv, 76. Born at Forli, Italy, Feb. 25, 1682; died at Padua, Italy, Nov. 5, 1771. An Italian physician and anatomist. He made exhaustive studies of the structure of diseased tissue both during life and postmortem, and as he was one of the first to investigate this subject he is one of the founders of pathological anatomy. From the time of the publication of Morgagni's researches morbid anatomy became a recognized branch of medical science.

Morgan, Lewis Henry, vi, 25. Born at Aurora, N. Y., Nov. 21, 1818; died at Rochester, N. Y., Dec. 17, 1881. American archæologist and anthropologist. He was first to give a scientific account of the organization and government of the Indian tribe.

Morse, Samuel F. B., viii, 17. Born at Charlestown, Mass., April 27, 1791; died at New York, April 2, 1872. American artist and inventor of the electric telegraph. He began life as a portrait painter, but turned his attention to invention, and in 1832 designed an electric telegraph. He applied for a patent in 1837, and in 1844 a line of telegraph was completed between Baltimore and Washington, an appropriation for its construction having been granted by Congress the year before.

Morton, Dr. William Thomas Greene, iv, 214. Born at Charlton, Mass., Aug. 9, 1819; died at New York, July 15, 1868. An American dentist, the discoverer of etherization. On October 16, 1846, Dr. Morton administered ether to a patient in the Massachusetts General Hospital, at Boston, and Dr. Warren performed a difficult operation, the removal of a tumor from the patient's neck. This operation inaugurated the era of painless surgery for which Dr. Morton's discovery is responsible.

Müller, Johannes, iv, 122. Born at Coblenz, Germany, July 14, 1801; died at Berlin, April 27, 1858. German physiologist and comparative anatomist. He was one of the founders of modern physiology.

Murdoch, William, vi, 207; vii, 158. Born at Auchinleck, Ayrshire, Aug. 21, 1753; died at Birmingham, Nov. 15, 1839. Scottish inventor. He was associated with Watt in Birmingham, and in 1795 first made use of illuminating gas at that place. He was the inventor of the oscillating steam-engine.

Musschenbroek, Peter van, ii, 280. Born at Leyden, Netherlands, March 14, 1692; died there Sept. 19, 1761. Dutch natural philosopher and mathematician. One of the discoverers of the Leyden jar. His discovery was made at about the same time as that of Dean von Kleist, but independently.

Newcomb, Simon, vii, 39. Born at Wallace, Nova Scotia, March 12, 1835; died in 1910. American astronomer. Professor of Mathematics in the United States Navy in 1861; in 1884, Professor of Mathematics and Astronomy at

a theory of spontaneous generation and of evolution of species.

Olbers, Heinrich Wilhelm Matthias, iii, 40. Born near Bremen, Germany, 1758; died at Bremen, March 2, 1840. German physician and astronomer. He discovered several comets and the planetoids, Pallas and Vesta, and discovered a method of calculating cometary orbits.

Owen, Sir Richard, iv, 207. Born at Lancaster, England, July 20, 1804; died at London, Dec. 18, 1892. English paleontologist and comparative anatomist. From 1836-1856, he was Hunterian Professor of Anatomy and Physiology in the London College of Surgeons. He was conspicuous in the field of microscopy, and in 1833 discovered the "Trichina spiralis" in the tissues of the human body.

Paget, Sir James, iv, 207. Born at Yarmouth, England, Jan. 11, 1714; died at London, Dec. 30, 1899. English physician and surgeon. He discovered the presence of "Trichina spiralis" in human muscular tissue while a student in St. Bartholomew's Hospital in 1833. At one time president of the Royal College of Surgeons.

Papin, Denis, vi, 88. Born at Blois, France, Aug. 22, 1647; died in 1712. French physicist. As early as 1688 he conceived the idea of making use of a piston working tightly in a cylinder, and a little later added the idea of producing a vacuum in a cylinder—steps toward the invention of the steam-engine.

Paracelsus, Philippus Aureolus, ii, 159. Born at Switzerland, Dec. 17, 1493; died at Salzburg, Sept. 23, 1541. German-Swiss physician and alchemist. He gave a great impetus to the study

of the mercury proving the correctness of the theory of atmospheric pressure.

Pasteur, Louis, iv, 217. Born at Dole, Jura, France, Dec. 27, 1822; died near St. Cloud, Sept. 28, 1895. Celebrated French chemist and microscopist. Noted for his studies on fermentation and his researches in bacteria. Remembered particularly for his experiments with anthrax bacillis and the prevention of the disease in domestic animals caused by this germ. Also for his experiments and demonstrations in the prevention of hydrophobia by inoculation.

Paul of Aegina, ii, 31. Born about 620; died about the year 690. A Byzantine physician. He was one of the Alexandrian school of physicians who was far ahead of his time in his knowledge of surgery. He discarded the prevalent idea of the supernatural cause of disease and practiced his profession along rational scientific lines. He performed many modern operations, among others those within the abdominal cavity.

Perraudin, iii, 145. A chamois hunter, who in 1815 noted the markings of glaciers on the rocks in the Alps and reached the correct conclusion that these scratches were caused by glaciers in former times. His conception was laughed at at first by scientists, but later accepted as a true explanation of what are now known as glacial scratches.

Peter of Abano, ii, 36. Born in 1250; died in 1315. A celebrated mediæval physician who advocated rational methods in the treatment of diseases, maintaining that such diseases were of natural rather than of supernatural causation. He was one of the first great men produced by

the University of Padua. He is remembered particularly for his teachings that the brain is the source of the nerves, and the heart the source of the vessels.

Petrie, W. M. Flinders, i, 28. Born June 30, 1853. An English Egyptologist who has made many important discoveries of Egyptian relics which give clues to the history of the early Egyptian civilization.

Piazzi, Giuseppe, iii, 40. Born at Ponte, Valtellina, Italy, July 16, 1746; died at Naples, July 22, 1826. Italian astronomer. On January 1, 1801, observed an apparent star which he supposed to be a comet. Later it proved to be the planet Ceres, occupying a position in space between Mars and Jupiter.

Pickering, Edward Charles, iii, 65. Born at Boston, July 19, 1846. American astronomer, Professor of Astronomy and Dir. Harvard College Observatory since 1876. Made exhaustive study of light and spectra of the stars. Made over one million measures of the light of stars with a meridian photometer invented by him. Author of "Elements of Physical Manipulation," and many papers on scientific subjects.

Pinel, Dr. Philippe, iv, 245. Born at St. André, Tarn, France, April 20, 1745; died at Paris, Oct. 25, 1826. French physician. In 1795, at La Saltpêtrière, an asylum for the care of the insane, he struck off the shackles from the inmates and took the revolutionary attitude of treating them as persons afflicted by disease, not "possessed by demons."

Planché, Gaston, iii, 246. French inventor. In 1859 he invented the first reasonably satisfac-

tory storage battery. His battery was constructed of sheets of lead immersed in dilute sulphuric acid.

Plato, i, 180. Born at Ægina, 429 or 427 B.C.; died at Athens, 347. Greek philosopher. He was a great ethical teacher, but seems to have had no clearly defined opinions as to the mechanism of the universe; no clear conception as to the origin of development of organic beings; no tangible ideas as to the problems of physics; no favorite dreams as to the nature of matter.

Playfair, John, iii, 131. Born at Benvie, Forfarshire, March 10, 1748; died at Edinburgh, July 19, 1819. Scottish physicist. One of the ardent champions of Hutton's theory of constant changes taking place in the earth's crust. With Lyell, he conceived that the changes on the surface of the earth have always been the same in degree as well as in kind. Modern physicists do not accept this.

Pliny (Caius Plinius Secundus), i, 265. Born at Como, Italy, 23 A.D.; died in the eruption of Vesuvius, 79 A.D. Celebrated Roman naturalist. He wrote his famous work on "Natural History" while campaigning as a soldier of the Roman Empire. It is a vast work in which some four thousand works are either cited or quoted from. In the history of scientific principles it may be virtually disregarded, but it is important in the history of the promulgation of knowledge.

Polybius, i, 201. Born at Megalopolis, Arcadia, Greece, 204 B.C.; died about 125 B.C. Celebrated Greek historian. It is through his wri-

tury, A.D. Astronomer, geographer, and mathematician. The last great astronomer of antiquity. His mathematical system of astronomy was accepted for several centuries until finally displaced by the system of Copernicus.

Pythagoras, i, 112. Born at Samos, Greece, about 582 B.C.; died at Metapontum, Magna Græcia, about 500 B.C. Famous Greek philosopher and mathematician. He is said to have been the first to advocate that the earth is a sphere.

Ramon y Cajal, Dr. Santiago, iv, 283. Born at Petitte de Aragon, Spain, 1852. Spanish physician and histologist. Professor of Histology in Barcelona and Madrid. Received one of the Nobel prizes, 1906.

Ramsay, Sir William, v, 86. Born at Glasgow, Oct. 2, 1852. Scotch chemist. In 1894 (with Lord Rayleigh) he discovered argon. He isolated helium, krypton, neon, and xenon. In 1896 he published "The Gases of the Atmosphere and the History of their Discovery."

Rawlinson, Canon, i, 82. Born at Chadlington, Oxfordshire, Nov. 23, 1812; died at Canterbury, Oct. 6, 1902. English theologian, historian, and Orientalist. His histories of the ancient Oriental peoples have thrown much light on the scientific knowledge of their time.

Rawlinson, Sir Henry, iv, 229; v, 9. Born at Chadlington, Oxfordshire, April 11, 1810; died at London, March 5, 1895. English Assyriologist. He wrote extensively on Assyriology, giving a clear insight into the status of science among the Assyrians and Chaldeans.

Rayleigh, Lord, v, 86. Born Nov. 12, 1842. English physicist. For eleven years he was sec-

retary of the Royal Society. He was associated with Prof. William Ramsay in the discovery of the new gas, argon, which forms approximately 1 per cent of the atmosphere.

Réamur, René, iv, 88. Born at La Rochelle, France, Feb. 28, 1683; died at Bermondiere, Maine, France, Oct. 18, 1757. French naturalist and physicist. He discovered the method of making the porcelain named for him and invented the Réamur thermometer. In the scale of this thermometer there are 80 degrees between the freezing-point and the boiling-point of water.

Rhazes, Arabian physician, ii, 24. Born at Raj, Persia, about 850; died about 932. An Arabian physician, philosopher and musician. He introduced the use of mercurial ointment, sulphuric and nitric acid, in therapeutics. He is credited with being the first physician to describe small-pox and measles accurately.

Roentgen, Professor Wilhelm Conrad, iii, 248. Born at Leinnep, Prussia, March 27, 1845. German physicist. He has made several important discoveries, but the importance of these is completely overshadowed by his discovery, in 1896, of the Roentgen rays, or X-rays. For this discovery he was awarded the Nobel prize in 1901.

Rougé, Olivier Charles de, i, 27. Born at Paris, April 11, 1811; died at Chateau Bois-Dauphin, Dec. 31, 1872. Celebrated French Egyptologist. Remembered particularly for his discovery of the prototypes of the Semitic alphabet in the early Egyptian hieratic.

Rumford, Count, iii, 208; v, 30. Born at Woburn, Mass., March 26, 1753; died at Auteuil, near

Paris, Aug. 21, 1814. An American scientist. As aide-de-camp and chamberlain at the court of the Elector of Bavaria, he reorganized the Bavarian Army. His greatest discovery, that heat is a form of motion, was discovered while boring cannon for the defense of Munich.

Rush, Dr. Benjamin, iv, 245. Born near Philadelphia, Dec. 24, 1745; died at Philadelphia, April 19, 1813. American physician. Remembered in particular for his attitude toward patients suffering from mental disorders.

Rutherford, Prof. Ernest, v, 105. Born at Nelson, New Zealand, 1871. In 1898, was appointed Professor of Physics in McGill University, Montreal. He has written extensively on the conduction of electricity through gases, and on radio-activity. In 1904 he published "Radio-activity."

Saint-Hilaire, Etienne Geoffrey, iv, 160. Born at Étampes, April 15, 1772; died at Paris, June 19, 1844. Noted French zoologist. He championed the theory of the transmutation of species against Cuvier, but the truth of his arguments was not fully appreciated until after his death.

Santos-Dumont, Alberto, vii, 266. Born at San Paulo, Brazil, July 20, 1873. Brazilian aeronaut. Experimented with balloons in 1898, and in that year constructed his first dirigible balloon. After building several balloons and having several narrow escapes, he finally, on October 19, 1901, won the Henri Deutsche prize of 100,000 francs by flying from the Aero Club at Saint Cloud around the Eiffel Tower and back

to the starting point in a few seconds less than half an hour.

Savery, Thomas, vi, 85. Born at Shilstone, near Modbury, Devonshire, about 1650; died at London, May, 1715. English engineer. He is remembered particularly for his invention of a machine for raising water from mines by means of steam power. This device, patented in 1698, represented the first application of steam power for mechanical purposes.

Scheele, Karl William, iv, 23. Born at Shalsund, Dec. 2, 1742; died at Köping, Sweden, May, 1786. A celebrated Swedish chemist. He discovered oxygen independently, and without knowing that Priestley had already discovered it. He also discovered many other important substances, such as arsenic acid, lactic acid, tartaric acid, ammonia, and chlorine, this last being of great value commercially for bleaching.

Schiaparelli, Giovanni Virginio, iii, 35. Born at Savigliano, Italy, March 4, 1835. Italian astronomer. The first to point out that meteor swarms move in the orbits of pre-existing comets, and are the débris of comets.

Schleiden, Dr. M. J., iv, 118. Born at Hamburg, April 5, 1804; died at Frankfort-on-the-Main, June 23, 1881. German botanist. The first to demonstrate the all-importance of cell-nucleii in the economy of the cell.

Schoenlein, J. L., iv, 208. A German physician who, in 1839, made the discovery that favus, a distressing disease of the scalp, is due to the presence of a microscopic vegetable organism. This was a step toward the later discovery

that many other diseases are caused by bacteria.

Schultze, Max Johann Sigismund, iv, 125. Born at Freiburg, Baden, March 25, 1825; died at Bonn, Prussia, Jan. 16, 1874. German anatomist and biologist. Remembered particularly for his researches on protoplasm, and his demonstrations that vegetable protoplasm and animal sarcode are to all intents and purposes identical.

Schwann, Theodor, iv, 119. Born at Neuss, Prussia, Dec. 7, 1810; died at Cologne, Jan. 14, 1882. Distinguished physiologist. He is remembered particularly as the founder of the cell-theory. He made important investigations of muscular and nervous tissues, and was the discoverer of pepsin.

Scrope, G. Poulett, iii, 132. Born at London, 1797; died Jan. 19, 1876. English geologist. In 1823 he published a classical work on volcanoes in which he claimed that volcanic mountains are merely accumulated masses of lava belched forth from a crevice in the earth's crust.

Servetus, Michael, ii, 168. Born at Tudela, Spain, 1511; burned at Geneva, Oct. 27, 1553. Spanish physician and philosopher. He discovered and described the pulmonary circulation, and that the fluids contained in veins and arteries are the same. He showed that the blood is purified by respiration in the lungs, and asserted that there are vessels in the lungs "formed out of vein and artery."

Siemens, Werner, vi, 178; vii, 181. Born at Lenthe, near Hanover, Dec. 13, 1816; died at Berlin, Dec. 6, 1892. German inventor and man-

ufacturer. He is noted for his experiments in electricity, his work having a direct effect in the final perfecting of the dynamo.

Siemens, Sir William, vi, 195. Born at Lenthe, near Hanover, April 4, 1823; died at London, Nov. 19, 1883. German-English physicist and inventor; brother of Werner Siemens. In 1859 he became a naturalized British subject. He made extensive researches in the field of heat and electricity.

Simpson, Sir J. Y., iv, 217. Born at Bathgate, Scotland, June 7, 1811; died May 6, 1870. Scottish physician. Noted for his introduction of chloroform as an anæsthetic about one year after Morton's demonstration of etherization.

Singer, Isaac M., ix, 97. Born at Oswego, N. Y., Oct. 27, 1811; died at Torquay, England, July 23, 1875. American machinist and inventor. He improved the sewing-machine, bringing it to a practical stage of perfection.

Sloane, Sir Hans, v, 4. Born at Killyleagh, County Down, Ireland, April 16, 1660; died at London, Jan. 11, 1753. British physician and naturalist. Virtually the founder of the British Museum. His collection of curios, which he turned over to the British Government for a nominal sum, formed the nucleus for the present museum.

Smith, William, iii, 74. Born at Churchill, Oxfordshire, England, March 23, 1769; died at Northampton, England, Aug. 28, 1839. An English surveyor who is known as "the Father of English Geology" through his studies of fossils. He discovered that fossils in rocks are arranged in regular systems, and that the order of succes-

sion of such groups of fossils is always the same in any vertical series of strata in which they occur.

Snell (or Snellius), **Willebrord,** ii, 119. Born at Leyden, 1581; died Oct. 30, 1626. Dutch mathematician. About the year 1621, while Professor of Mathematics at Leyden, he discovered the law of refraction.

Spallanzani, Lazzaro, iv, 86. Born at Scandiano in Modena, 1729; died in 1799. Remembered chiefly for his discoveries and investigations in the biological sciences. He refuted the evidence of Needham that minute organisms form spontaneously in solutions of meat in water after boiling, by demonstrating conclusively that if properly protected from the atmosphere no organism will form. He discovered the function of the ovum and spermatozoon, and demonstrated that digestion is a chemical process by an ingenious use of tubes filled with food introduced into the stomach.

Spencer, Herbert, iv, 268. Born at Derby, April 27, 1820; died at Brighton, Dec. 8, 1903. English philosopher, founder of the system known as synthetic philosophy. He studied engineering and during 1837-46 was employed as a railway engineer. From 1846 he devoted himself to literary work, acting as sub-editor of the "Economist" from 1848 to 1853. In 1850 he published "Social Statics"; and in 1855, "Principles of Psychology." He began his "Synthetic Philosophy" in 1860, completing it in 1896. He was in sympathy and closely in touch with the work of Darwin and Huxley, and in his writings he tried "to express in a sweeping general formula the

belief in progress which pervaded his age." He was essentially a thinker and writer, rather than an active worker in scientific fields.

Spurzheim, Dr. Kasper, iv, 248. Born at Longwich, near Treves, Dec. 31, 1776; died at Boston, Nov. 10, 1832. A German phrenologist. He was a disciple of Gall, and wrote a physiognomical system with him. He wrote also on philosophy and anatomy.

Stahl, George Ernst, iv, 6, 185. Born at Auspach, 1660; died at Berlin, 1734. German physician and chemist. Famous as the author of the phlogiston theory (q.v.). Champion of the "Animist" theory in medicine.

Stephenson, George, vi, 114; vii, 124. Born at Wylam, near Newcastle, June 9, 1781; died near Chesterfield, Aug. 12, 1848. English inventor, the perfecter of the locomotive. As early as 1814 he constructed a locomotive that could propel itself along the rails, and in 1825 a locomotive made by him actually hauled a train of cars with passengers. His locomotive "Rocket," made in 1829, however, is the prototype of modern locomotives.

Stevinus, Simon, ii, 102. Born at Bruges, 1548; died at The Hague (on Leyden), 1620. Celebrated Dutch mathematician. About 1600 he invented a carriage propelled by sails, in which he carried the Prince of Orange and six other passengers at a speed said to have been much faster than that of horses. In the history of science he is remembered as one of the founders of the science of dynamics and the science of statics.

Strabo, i, 255. Born at Amasia, Pontus, about 63 B.C.; died about 24 A.D. Celebrated Greek

geographer. Through his writings a good idea of the status of the sciences in his day is gained. He considered the earth a globe, and had a very definite idea of its size. The habitable portion, according to him, extended from Ireland to Ceylon.

Struve, F. G. W., iii, 58. Born at Altona, Germany, April 15, 1793; died at St. Petersburg, Nov. 23, 1864. A German Russian astronomer. He is remembered particularly for his researches on double stars.

Swammerdam, John, ii, 297. Born at Amsterdam, Feb. 12, 1637; died there Feb. 15, 1680. Dutch naturalist. He was educated for the ministry, but turned to the profession of medicine. Later he devoted himself to the study of insects, and his work laid the foundation of the modern science of entomology.

Sydenham, Thomas, ii, 189. Born in Dorsetshire, England, 1624; died at London, December, 1689. Famous English physician. He studied predisposing causes of diseases, and anticipated modern practice in his methods of treating them. In general terms his was what might be termed "rational" treatment. He is remembered particularly for his introduction of the use of laudanum.

Sylvius, Franz, ii, 186. Born at Hanan, Prussia, 1614; died at Leyden, 1672. Celebrated German physician. He founded the "Iatrochemical" school of medicine, whose fellows used medicines and did not accept the "humoral" pathology. One of the fissures in the brain (fissure of Sylvius) is named for him.

Symington, William, vii, 67. Born at Lead-

about 372 B.C.; died 288 or 287 B.C. Greek philosopher. He was a disciple of Aristotle. Because of his work on botany, called "The Natural History of Development," he is called the "father of botany."

Thompson, Benjamin. (See Count Rumford.)

Thomson, Prof. J. J., v, 92. Born near Manchester, Dec. 18, 1856. English physicist. Professor of Physics, Royal Institution, London, since 1905. Especially noted for his researches in electricity and magnetism, and his exhaustive writings on these subjects. May be said to be the discoverer of the negative "electron," or unit "corpuscle" of electricity.

Thomson, Thomas, iv, 44. Born at Crieff, April 12, 1773; died near Holy Loch, July 2, 1852. British chemist. He discovered a large number of chemical compounds, such as chlorochromic and hyposulphurous acid, and many salts.

Thomson, William. (See Lord Kelvin.)

Torricelli, Evangelista, ii, 120. Born at Piancaldoli, Italy, Oct. 15, 1608; died at Florence, Oct. 25, 1647. Italian mathematician and physicist. He was a friend of Galileo, and his successor as professor at Florence. He is remembered particularly for his invention of the barometer in 1643.

Treviranus, Gottfried Reinhold, iv, 159. Born at Bremen, Feb. 4, 1776; died Feb. 16, 1837. German naturalist. He was one of the early workers in biological fields, and one of the first to suggest the name "biology" for that science.

Trevithick, Richard, vi, 103; vii, 75. Born at Cornwall, England, April 13, 1771; died April 22, 1833. Engineer and inventor of the locomotive.

structed a system of medicine which had quite a following until after his death. He coined and first used the word "gas," and is said to have demonstrated the necessity of using the balance in chemistry.

Vesalius, Andrew, ii, 164. Born at Brussels, Dec. 31, 1514; died in the Island of Zante, Oct. 15, 1564. Noted Belgian physician and anatomist. He is called the "greatest of anatomists." His work, "De corporis humani fabrica, libri septem" was the first comprehensive and systematic work on humane anatomy.

Virchow, Rudolf, iv, 127; v, 188. Born at Schivelbein, Pomerania, Oct. 13, 1821; died at Berlin, Sept. 5, 1902. Celebrated German physician, anatomist, and anthropologist. He was the founder of cellular pathology. Throughout his life he was active as a teacher, in laboratory work and hospital clinic. During his later years he was also active as a statesman.

Volta, Alessandro, iii, 230. Born at Como, Italy, Feb. 18, 1745; died there March 5, 1827. Celebrated Italian physicist. He is famous for his invention of the voltaic pile. This invention furnished a method of generating galvanic electricity, and is the direct prototype of modern galvanic batteries. It was one of the most revolutionary inventions in the field of electricity. Volta also invented an electroscope, electrophore and condenser.

Von Baer, Karl Ernst, iv, 122. Born at Esthomia, Russia, Feb. 28, 1792; died at Dorpat, Nov. 28, 1876. Celebrated Russian naturalist and embryologist. Von Baer's studies in embryology were the basis of Schwann's discovery that "there

circuit, he discovered the superiority of wire over chain as a conducting medium.

Watt, James, iv, 14. Born at Greenock, Scotland, Jan. 19, 1736; died near Birmingham, Aug. 19, 1819. Celebrated English engineer and mechanician, the perfecter of the practical steam engine. Among his scientific achievements he claimed to have first discovered the composition of water. Englishmen credit Cavendish with this discovery, but in France Watt's claim is very generally accepted.

Weber, E. H., iv, 263. Born at Wittenberg, Prussia, June 24, 1795; died at Leipsic, Jan. 26, 1878. German physiologist. After exhaustive experiments to test the effects of various nervous stimuli, he reached conclusions which later Fechner christened "Weber's fundamental law of psycho-physics."

Wedgwood, Josiah, iii, 206. Born at Burslem, England, July 12, 1730; died near Newcastle-under-Lynne, Jan. 3, 1795. Celebrated English potter. Inventor of the clay pyrometer, which first enabled scientists to gauge high temperatures accurately.

Weismann, August, iv, 179. Born at Frankfort-on-the-Main, Jan. 17, 1834. Noted German zoologist. He promulgated a theory (in 1883) which denies that individual variations are transmissible. This view antagonizes the Lamarckian conception of acquired variations, which was generally conceded to complement the Darwinian factor of natural selection in effecting the transmutation of species.

Wells, Dr. Horace, iv, 213. A dentist of Hartford, Connecticut, who in 1844 administered ni-

trous oxide gas and performed the operation of extracting a tooth painlessly. This was two years before Morton discovered etherization.

Wells, Dr. W. C., iii, 184. Born in America, but spent his life in Great Britain. In 1816 he published his "Essay on Dew," in which the explanation of its formation was given, solving a problem that had long puzzled the philosophers.

Werner, Abraham Gottlob, iii, 131. Born at Wehrau, Upper Lusatia, Sept. 25, 1750; died at Dresden, June 30, 1817. German mineralogist and geologist. He propounded the "Neptunian theory," that "in the beginning all the solids of the earth's present crust were dissolved in the heated waters of a universal sea."

Westinghouse, George, vii, 142. Born at Central Bridge, N. Y., Oct. 6, 1846. American inventor. At the age of fifteen he invented an air-brake, which he continued to improve to meet changing conditions, a modification of this first brake being in use almost universally on steam and electric cars.

Wheatstone, Sir Charles, vi, 178. Born at Gloucester, England, in February, 1802; died at Paris, Oct. 19, 1875. English physicist and inventor. In 1837 he patented a telegraph, an instrument that was supplanted by the invention of Morse. He invented the concertina, the stereoscope, and many improvements in the field of electricity.

Whitney, Eli, ix, 9. Born at Westborough, Mass., Dec. 8, 1765; died at New Haven, Conn., Jan. 8, 1825. The inventor of the cotton-gin—the machine that makes possible the handling and subsequent manufacturing of the great cotton

crops to-day. Whitney's machines were manufactured by others before he could secure a patent. He made a fortune, however, in manufacturing firearms at Whitneyville, Conn.

Wilkinson, Sir John Gardner, i, 27. Born at Hardendale, Westmoreland, Oct. 5, 1797; died Oct. 29, 1875. English Egyptologist. His writings have furnished important information as to the status of science among the ancient Egyptians.

Wiseman, Richard, ii, 184. Born in 1625; died in 1686. A celebrated English surgeon. He was in the service of all the Stuart kings. He was first to advocate primary amputation in gunshot wounds, and to introduce the treatment of aneurism by compression.

Wohler, Friedrich. (See Liebig and Wohler.)

Wollaston, William Hyde, iv, 41. Born at East Dereham, Norfolk, Aug. 6, 1766; died at London, Dec. 22, 1828. Noted English physicist and chemist. He invented the camera lucida and goniometer, and discovered palladium and rhodium. He also discovered the ultra-violet rays in the solar spectrum.

Wright, Orville, vii, 288. Born at Dayton, Ohio, Aug. 19, 1871. Inventor (with his brother Wilbur), of the aeroplane flying-machine. First tests of flying machine made in 1903, at Kitty Hawk, N. C. Successful long distance tests made near Dayton, Ohio, 1905. With his brother, first demonstrated that the heavier-than-air flying-machine is a practical mechanism.

Wright, Wilbur, vii, 288. Born near Millville, Ind., April 16, 1867. Inventor (with his brother Orville), of the aeroplane flying-machine. Made

ENCYCLOPÆDIC GENERAL INDEX

(This Index brings together, under one alphabet, all the important technical terms and the most prominent names of men in all departments of science, theoretical and applied. It does not ordinarily define terms, nor does it aim to give biographical data except insofar as these are necessary to make the reference specific. Its purpose is to analyze the text in a m nner at once detailed and comprehensive, with the sole object cf guiding the reader to the text itself. Nevertheless, the references are so phrased as to convey, first and last, an enormous amount of information.

The figures in heavy type refer to volumes; those in ordinary type to pages.

For concise definition of terms see the Technical Index and Glossary; for Biographical data see the Biographical Index, both in the present volume.)

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